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EDITORIAL

INTERNAL PROTECTIVE COATINGS FOR LATEX CONTAINERS

Previous investigations carried out in the Institute by Dr. Rhodes and Mr. Sekar have proved that the discolouration of preserved latex, in which a blue-black discolouration and deposit are produced, is due to contamination with iron from the container. It has been shown that the discolouration is due to the formation of sulphide of iron and that it is increased if the latex undergoes putrefaction before the addition of ammonia.

Numerous proprietary filming materials and various protective paints of known composition have been tested and their suitability or otherwise is discussed. As will be seen most of the materials are unsatisfactory while a few are satisfactory but expensive.

It is satisfactory, however, to note that the filming mixture prepared in the Institute laboratories has proved satisfactory, and is the logical outcome of previous researches carried out in the Institute. A brief reference to this treatment of containers was also published in the *Annual Report 1934*.

THE EFFECT OF THE CONDITIONS OF DRYING ON THE AGEING PROPERTIES OF RUBBER

The article by Mr. Hastings on the effect of the conditions of drying on the ageing properties of sheet rubber is of considerable importance in relation to the more rapid drying and smoking of sheet rubber which is now being practised. The problem is also under investigation in relation to the plasticity of raw rubber, which is probably influenced by the temperature and other conditions of drying.

Complaints have been received from manufacturers both in respect of poor ageing properties and variability of plasticity of sheet rubber.

In relation to poor ageing properties, although the use of proprietary anti-oxidants by manufacturers will counteract poor ageing, there are probably processes in which such anti-oxidants

are not employed and in which it is desirable that the raw material without further treatment should possess good ageing properties.

It would appear that the smoking process is of some importance in the drying of rubber in relation to ageing and this is now being investigated, in order to elucidate if possible the factor or factors concerned.

In view of the results obtained, a modification in the procedure of drying and smoking in certain types of drying and smoking-houses may be essential.

The poor ageing properties of sheet rubber prepared from a very dilute latex are also of significance, and indicate the probable reduction of natural anti-oxidants in the raw rubber, when latex is considerably diluted before coagulation.

In this connection several enquiries have been addressed to the Institute in respect of the Subur type of smoke-house recommended by the Institute, and it may be pointed out that, in this smoke-house, smoking and drying are carried out simultaneously, the period of drying depending largely on the temperature employed. The Subur smoke-house differs from the older type of smoke-houses in respect only of its greater efficiency and ease of handling the rubber on portable racks in a one-storey chamber. There is, therefore, no reason why this type of smoke-house should have any detrimental effect on the ageing properties of the rubber.

Experiments on Economic Tapping Systems

The article by Mr. Sharp gives the results of the second year's tapping of a series of tapping systems being carried out by the Botanical Division of the Institute on Seventh Mile Estate. The results confirm those obtained during the first year's tapping.

The yields on the A.B.C. periodic systems are gradually rising in relation to those on the control system of alternate-daily (A.D.) tapping without rest.

The results also indicate that in the A.B.C. systems, the shorter periods of tapping and rest are preferable during the early stages of transition from the normal A.D. systems, although during the second year of tapping under this system the yields are not significantly different.

The Sunderland systems are still less satisfactory than the A.B.C. systems.

While the double-four system (*i. e.* two cuts on opposite sides of the tree at different heights) continues to be satisfactory in respect of yield and lower cost of tapping compared with the A.D. system, the amount of scrap rubber is higher and the bark consumption is greater. In consequence of this higher bark consumption it has been found necessary to convert this system to

an A.B.C.D. periodic system, retaining the double-cut every fourth day on the sections in tapping.

Use of Weed-killers in the Control of Natural Covers

Considerable interest has been taken during the last few years, especially in Great Britain, in the eradication of weeds by the application, by spraying, of certain toxic substances such as sodium chlorate, sodium arsenite and sulphuric acid. In particular, large quantities of sulphuric acid have been used by farmers due both to propaganda by the manufacturers and to the success obtained.

The success obtained in one country may, however, not be realized in another on account of several varying factors. Thus where labour cost is low, as in Malaya, eradication by digging may be more economical than the use of weed-killers. Secondly, in the case of weeds like lalang grass with a strong root system, only the above-ground portions of the plant may be destroyed, except by repeated applications of uneconomic doses. Thirdly, climatic conditions, especially the absence of seasons and the heavy rainfall in the tropical rainfall belts, may be disadvantageous.

A number of trials carried out on estates are described in the article by Mr. Akhurst.

It will be seen that the results obtained on different estates are variable. Sodium chlorate and arsenical weed-killers are most effective on bracken and stagmoss, while lalang and other grasses and bush covers are not destroyed. A preliminary spraying, however, which kills the above-ground portion of the weeds, will lessen the cost of subsequent eradication by digging.

Further records from estates which have carried out spraying trials will be welcomed.

Replanting

One of the most important problems in the plantation rubber industry at the present day is that of replanting. The importance of this problem has been accentuated by the present Rubber Regulation Scheme, which prohibits new planting on virgin land, but permits the replanting of 20 per cent of the existing stand during the period of " restriction " of exports.

Another factor which has rendered replanting an economic proposition is the development of high-yielding planting material to replace the present heterogeneous seedling stand, in which deterioration is proceeding slowly or rapidly on different sites, due to losses of trees by root diseases and to soil deterioration caused by the practice of clean-weeding on most estates during the last 25 to 30 years.

Mr. Moore's article, which is a reprint of a lecture given by him at the Annual Conference of the Incorporated Society of Planters held in Malacca in September and published in *The Planter* (Vol. XVI, No. 10, October 1935), discusses the pros and cons of replanting *vis-a-vis* the manuring of the present stand of " mature " seedling rubber trees, refers briefly to the treatment necessary for the eradication of root diseases and gives an estimate of the probable cost of bringing into bearing such replanted areas, including the probable cost of a manurial programme.

The facts and deductions stated show that replanting is a sound economic proposition and this is confirmed by results already being obtained by progressive estates on which replanting was commenced several years ago.

Quality of Sole Crepe

As is well known, raw rubber undergoes considerable changes at different temperatures. This is one of the principal reasons why vulcanized rubber is used in preference to raw rubber for most applications. Sole crepe is one of the few applications of raw rubber as such without undergoing the process of vulcanization.

Apart from tackiness caused by exposure to direct sunlight, raw rubber becomes very hard and stiff in the cold and loses almost entirely the elastic and resilient properties which it possesses at higher temperatures. These variations are responsible for complaints made by consumers who are not well acquainted with these changes. The note by Dr. Rhodes, on the toughness of sole crepe and the variation in resiliency indicated by the tests carried out on the same sample at different temperatures, suggests how these complaints arise and shows that they are often unjustifiable.

Creaming of Latex with Gum Tragacanth

The article by Dr. Rhodes and Mr. Sekar describes a process, for which a British Patent has been obtained by the Institute, for the improvement in the creaming of latex by means of gum tragacanth with small quantities of alcohol added, which does not affect the quality of the creamed product.

Some grades of gum tragacanth have very poor creaming properties, but the reason for this is not known.

Creaming of Latex with Tragon Seed Gum

The article by Dr. Rhodes and Mr. Sekar is a copy of a British patent granted to the Institute for the creaming of latex with carob seed gum, known also as Tragon Seed gum, on which experimental investigation has been carried out at the Institute.

In many respects the use of this gum is more satisfactory than the use of gum tragacanth, since many grades of the latter have been shown to have very poor creaming properties, although the reason for this is not known.

The Specific Gravity of Rubber in Latex

The specific gravity of rubber in latex is of both academic and commercial interest. Its commercial importance is in relation to the specific gravity of latex which is now an important commercial product for which a table of specific gravities has been adopted by the Rubber Trade Association, London.

In a previous article published in the *Journal* (Vol. 5 p. 234), Dr. Rhodes concludes that the true specific gravity of the rubber in latex is 0.902 which is in close relationship with a figure of 0.901 estimated by Scholz and Klotz.

In an article in the *India Rubber Journal*, now reprinted in this journal, de Vries, who had arrived at a figure of 0.914, criticizes the figure obtained by Rhodes. In the same journal, Rhodes reviews de Vries's criticism and has amended the figure to 0.9064.

The difference between de Vries's figure of 0.914 and the amended figure of 0.9064 is still comparatively large, as is also this latter figure and that of the corrected value of 0.916 derived from the Rubber Trade Association table. The reason for this is not at present clear. The figures for "commercial" latex in the zone covered by the Rubber Trade Association table and Table III in the article by Rhodes differ only slightly and it is unlikely that the differences will disturb either dealers or users.

INTERNAL PROTECTIVE COATINGS FOR LATEX CONTAINERS

Investigations on Internal Protective Coatings for Latex Containers and their value in Minimising Discolouration in Preserved Latex

BY

Edgar Rhodes and K. C. Sekar

Introduction

In a previous publication (1) the present authors have discussed fully the causes of discolouration in preserved latex and have shown that the iron drum which is in common use as a latex-shipment vessel is in itself a pre-disposing factor to the discolouration of latex. Users do not however look with favour on the substitution of a non-metallic container for the steel drum, and since suitable alternative metallic containers are prohibitive in cost, there remains little alternative but to endèavour, by the internal application of some protective medium, to reduce to a minimum the objectionable effects of the iron drum on its contents.

Since discolouration is due to the formation of dark-coloured colloidal and amorphous sulphides of iron, a satisfactory drum-coating medium should prevent contact of the latex with the iron of the drum, and also if possible react with any sulphur bodies which may be liberated in the latex, to form sulphides which are either white in colour or so nearly white that when present in latex they are not detectable by the eye.

It is essential that the coating should not be so brittle as to crack or flake away from the metal when drums are roughly handled in transit. If flaking occurs, serious contamination of the latex may result. The requirement is a tough, elastic film which will adhere well to the metal and which will not be appreciably affected by long contact with ammoniated latex, except in so far as it may combine with sulphur bodies to produce a white product.

The present paper describes tests which have been made on a great variety of paint-like preparations some of which were proprietary and others which were compounded in the laboratory.

In testing the various preparations, the fact has been kept in mind that, in the majority of cases, the preparation must be applied to the inside of an already-assembled drum having at most two small apertures. This implies that preparations which

are normally slow to dry and harden do not commend themselves, because the drying time in the interior of a drum is necessarily longer than in freely-circulating air. Further, the only method of application available to most estates is that of pouring an excess of the preparation into the drum, rolling, turning end over end and finally running off the excess material. The construction of most drums does not lend itself to easy and complete drainage so that the only readily available method of application must be considered wasteful as well as troublesome. This fact suggests in turn that suitable materials should be such as are effective in a single application or coat. In all cases therefore tests have been confined deliberately to metal carrying one coat only of any given preparation.

Experimental

Method of Testing

The laboratory technique adopted for testing the suitability of the various media was empirical and was based largely upon the investigations which were made in connection with the earlier investigation (*loc. cit.*) into the causes of discolouration.

Strips of metal cut from an ordinary latex drum were given one coat of the material to be tested, by dipping and allowing to drain. After drying by exposure to free air for 24 hours at laboratory temperature, they were taken for test or if not reasonably dry they were recorded as probably unsuitable. In the course of all tests, unpainted strips were used as controls for purposes of comparison.

Two tests, which in practice were found to differ in severity, were applied to each material. These were:—

Test (i)—The simple Immersion and Storage Test and

Test (ii)—Test by partial Putrefaction prior to Ammoniation and Storage

The details of each test follow:—

Test (i)—The simple Immersion and Storage Test

In this test coated strips and their uncoated controls were immersed to within one-half inch of their length in latex which had been ammoniated to approximately 1 per cent NH_3 while still in a fresh condition. They were then stored for a period of six weeks during which periodical observation of the degree of discolouration of the latex was made. The period of six weeks was chosen as being the approximate and reasonable period of time which might elapse between despatch from the estate and examination by the buyer at destination.

Test (ii)—Test by partial Putrefaction prior to Ammoniation and Storage

This test is much more drastic than the simple immersion test, and under it many coating media, which appeared fairly satisfactory under the conditions of the first test, permitted the induction of considerable discolouration in the latex and accordingly came under suspicion. The technique consisted in immersing the coated and uncoated strips in fresh latex containing no preservative, and allowing the whole to stand for a period of four hours before adding ammonia as preservative. During this initial four-hour period prior to ammoniation some incipient putrefaction occurs in the latex and the products of this biological activity have a particularly severe action on iron. After having ammoniated the latex to approximately 1 per cent NH_3, it was stored for six weeks in contact with the metal strip, colour observations being made as in Test (i).

In both tests, at the end of the storage period and after final colour observations had been made on the latex, the strips were removed, washed with water and the condition of the filming material appraised. Media which under both tests prevented latex discolouration and which in addition were present as a hard, continuous but not brittle film at the end of the storage period were adjudged satisfactory; where very slight discolouration occurred in the latex, the medium was classified as imperfect and where appreciable discolouration was apparent, as unsatisfactory. The unsatisfactory media showed in practically every case appreciable softening and/or loosening of the film at the end of the storage period.

Proprietary Materials tested

It was at first considered likely that among the proprietary brands of paints and protective solutions which were available in Malaya and which could be obtained from Europe some would be found which combined cheapness with efficiency, and an examination of a number of proprietary materials of different general types was made. In most cases the manufacturers were preinformed of the requirements and supplied media which were expected to be satisfactory. The results of the examination of these materials are summarised in Table I.

The tests on the proprietary materials indicated that the only really satisfactory material was preparation No. 10 of which the base consisted of chlorinated rubber. In addition, preparation No. 9 containing chlorinated naphthalene showed promise, together with No. 24 which is in the main a derivative of rubber, and No. 13 which is a patented and rather expensive preparation

TABLE I

Key No. of paint	Type of base	Observations on drying rate	Condition of film after six weeks' storage of painted strip in latex	Suitability of paint as judged by degree of discolouration in Tests (i) and (ii)	General Remarks
1	Bituminous	Rather slow	—	Unsatisfactory	Unsuitable
2	„	Satisfactory	Continuous. Soft	„	„
3	„	„	„ „	„	„
4	„	Rather slow	„ „	„	„
5	„	„ „	„ „	„	„
6	„	Too slow	„ „	Imperfect	Unsuitable because of slow drying
7	„	„ „		Unsatisfactory	Unsuitable
8	Pigment, in oil vehicle	Satisfactory	Softened. Fell away	Satisfactory	Unsuitable because film leaves metal
9	Chlorinated Naphthalene	Satisfactory	Continuous. Hard	Imperfect	Fairly satisfactory
10	Chlorinated Rubber	Satisfactory	„ „	Satisfactory	Suitable
11	Soluble bakelite	„	„ Soft	Unsatisfactory	Unsuitable
12	„	„	„ Fairly hard	„	„
13	„	„	Continuous. Hard	Imperfect	Fairly satisfactory
14	Not known	„	Softened. Fell away	Unsatisfactory	Unsuitable
15	„ „	„	„ „	„	„
16	„ „	„	Continuous. Soft	Imperfect	Unsuitable. Film too soft
17	„ „	„	„ Fairly hard	Unsatisfactory	Unsuitable
18	„ „	„	Continuous. Soft	„	„
19	„ „	„	„ „	Imperfect	Unsuitable. Film too soft
20	„ „	„	Fell away	Unsatisfactory	Unsuitable
21	„ „	„	Film breaking	„	„
22	Rubber derivative	„	Continuous. Hard	„	„
23	„	„	„ Soft	„	„
24	„	„	„ Hard	Imperfect	Fairly satisfactory
25	Not known	„	„ Soft	Unsatisfactory	Unsuitable

of soluble bakelite. Chlorinated rubber and chlorinated naphthalenes are obtainable on the open market and this fact prompted further tests with media compounded in the laboratory from these bases.

Laboratory-compounded Preparations from proprietary Bases

Twelve different mixtures containing the chlorinated rubber "Pergut" with suitable solvents, softeners and plasticisers in different proportions, were subjected to the tests and all gave very satisfactory results. It was felt, however, that the process of compounding would be too difficult for the average estate and that the cost would be too great.

Twenty-three preparations containing chlorinated naphthalenes and mixtures of these bodies with bituminous substances as softeners, were prepared and tested. They were deemed to be unsuitable on grounds of difficulty of preparation and application. Many were in any case unsuitable because they permitted the induction of discolouration.

At this stage in the investigation the only reasonably satisfactory material which could be obtained in Malaya was the soluble bakelite preparation (No. 13) which is sold under the name of "Tropelite Black". This material has since been tested on a larger scale in large bulking tanks and trial drum shipments and, although not perfect, is nevertheless effective in minimising though not preventing discolouration. It is, however, too expensive for general adoption. The proprietary preparations Nos. 9, 10 and 24 were not and still are not available in Malaya.

The materials tested up to this stage had without exception been of the type which might protect iron from contact with latex but they were not compounded of substances which could readily react with any active sulphur bodies which might be produced in the latex. Since so little success had attended trials with the simple protective media, attention was turned to the production of a reactant filming medium. The aim was to produce a film containing a chemical substance which would react preferentially with latex-sulphur bodies to produce a white sulphide rather than the black sulphide of iron. Zinc oxide at once suggested itself as a suitable and cheap substance and laboratory tests were made with filming media containing zinc oxide as the essential principle.

Preparations containing Zinc Oxide

(a) Zinc Oxide in an Oil Vehicle

Metal strips treated with paints in which zinc oxide was dispersed in an oil vehicle proved unsuitable. Latex discolouration did

not occur, but the film softened, fell away from the metal and contaminated the latex with its oily vehicle. The failure was judged to be due to an incorrect choice of vehicle.

(b) Zinc Oxide in Rubber Solutions

Solutions of rubber in an organic solvent were used as a vehicle for zinc oxide. They gave zinc oxide films which adhered well to metal and which prevented latex discolouration. Rubber solutions are troublesome and expensive to prepare on estates and the obvious substitute was latex itself.

(c) Zinc Oxide-Latex Films

A number of zinc oxide-latex films were tested containing different proportions of zinc oxide and ammoniated latex. Very good results were obtained with these films. It remained to choose a mixture in which the proportion of zinc oxide was high enough to prevent latex discolouration but not so high that the deposited film of rubber and zinc oxide would be hard, lacking in adhesive power and likely to strip away from the metal. It was found that for best results the filming medium should contain approximately 20 per cent by weight of zinc oxide calculated on the weight of the ammoniated latex vehicles. In laboratory tests this filming medium gave consistently satisfactory results, and near the end of 1934 instructions for the use of this medium were first issued to an estate. The instructions are:—

"Take 2 lbs. of zinc oxide and mix to an extremely smooth paste with one quart of water. Mix this paste very thoroughly with one gallon of ammoniated latex containing 0.7 per cent ammonia. The mixture is now ready for use as a filming medium.

It is inadvisable to prepare more of the complete filming agent than will suffice for one day's supply of latex. A week's supply of the zinc oxide-water paste can, however, be prepared without danger. This should be thoroughly stirred before drawing the daily supply for admixture with the ammoniated latex vehicle. Before application, the filming mixture should be thoroughly stirred because the zinc oxide tends to settle out. Filming is carried out by pouring an excess of the mixture into a clean drum, rolling, and turning end over end, so as to film all internal surfaces. The excess filming agent is then drained out and the drum is exposed to the sun to dry the internal film. When the film is dry the drum is then ready for filling with ammoniated latex."

Where second-hand oil drums are used, it is important that drums which have been cleaned should be filmed within a few hours. Rust spots rapidly develop on the inside of wet, oil-free

drums. If rust spots are present, the applied film may be unsatisfactory because either the rust spots may not be completely covered or the film, if continuous, may not adhere firmly to the metal.

Large-scale Latex shipment Trials with Drums filmed with Latex-Zinc Oxide Medium

Large-scale latex shipment trials of several thousand gallons in latex-zinc oxide filmed drums were made early in 1935 by Mr. J. S. Laird, the Manager of Jemima Estate. These shipments were made on the basis of the laboratory tests set out above, and the customary cautious but time-consuming intermediate stages of small-scale trial shipments were thereby eliminated. Our thanks are due to him for the confidence which he showed and which proved fortunately not to be misplaced. Mr. J. B. Crockett, the President of Heveatex Corporation, Melrose, Mass., U.S.A., who in the fact of being willing to accept and report to us fully on latex from such consignments, rendered an equally great service.

A number of large-scale consignments have demonstrated that when the latex-zinc oxide filming medium is carefully applied, latex may be expected to arrive at destination in a good white condition. The film itself adheres well to the metal and cases of film-stripping in transit are few. These trials have demonstrated adequately the effectiveness of the film against discolouration caused by the metal container.

The trials have also demonstrated that the film possesses one disadvantage in that it tends to reduce the stability of the latex. We are advised however that if the buyer is previously made aware of the fact that drums have been filmed, he can in nearly all cases correct this reduction in stability without serious difficulty.

Discussion

The work on latex drum-filming media is a natural corollary to the earlier investigations (1) on the causes of latex discolouration. The effectiveness of the latex-zinc oxide medium which was developed after many fruitless tests on proprietary protectives, provides in itself a confirmation of the correctness of the original postulate that latex discolouration is due to the formation of amorphous and colloidal sulphide of iron within the latex. The substitution of zinc for iron as the reactant metal should, if the postulate be correct, result in the formation of white and therefore to the eye indetectable sulphides. Such has proved to be the case.

Within the last few weeks a British Patent No. 434,214 by the Metallgesellschaft Aktiengesellschaft has become available to

us. This patent provides for the addition of free zinc oxide to the preserved latex itself in order to prevent discolouration. In our treatment of the problem such a procedure was considered undesirable and was purposely avoided. The chief reason was that users might object to the deliberate addition of free powders such as this to latex before shipment. In the latex-zinc oxide films described, the zinc oxide present is held in a rubber matrix and is not free to enter the body of the latex. Further, the product of its reaction with the sulphur bodies of the latex, namely zinc sulphide, must itself remain to a large extent bound in that matrix. It is considered that the latex-zinc oxide film has the effect of preventing discolouration while giving rise to the minimum of what might be termed contamination.

It has been observed that the latex-zinc oxide films tend to reduce stability. This might have been expected but it is difficult to envisage how it can be avoided. The reduction in stability is almost certainly due to the formation of traces of soluble ammonium zincate by the action of ammonia on the zinc oxide film. The traces of zinc salt thus brought into solution, would naturally tend to reduce stability.

It is pointed out that the latex-zinc oxide film has not been tested by us in shipment trials with centrifugally concentrated latex. Because the filming is known to reduce stability, it is possible that where the dry rubber content is of the order of 60 per cent and where the concentrate is not heavily stabilised but preserved solely with ammonia, the reduction in stability may have more serious effects than are found with preserved field latex.

Similar remarks would apply but probably to a lesser degree in the case of gum-creamed latex. Producers of centrifugal and gum-creamed latex are therefore advised to proceed with caution in the use of the latex-zinc oxide drum-film and to make small trial shipments before attempting bulk consignments. It is also the fact that high natural stability in preserved normal latex is considered essential by a few users, and producers of such latex are advised wherever possible to consult the user before commencing the practice of filming with the latex-zinc oxide medium.

Summary

Tests on various drum-filming media as preventives of latex discolouration are described.

A simple filming medium effective against discolouration and compounded from latex and zinc oxide has been developed. Its possible disadvantage on the grounds of reduction of stability is discussed.

Literature cited

(1) Rhodes, Edgar and Sekar, K.C., *J.R.R.I.M.* **5** (1934) 176

Kuala Lumpur,

1st November, 1935

THE EFFECT OF THE CONDITIONS OF DRYING ON THE AGEING PROPERTIES OF SHEET RUBBER

BY

J. D. HASTINGS

Part I

Introduction

The amount of rubber exported from the East in liquid form as concentrated or normal latex has increased steadily during recent years, but it is still small in comparison with that exported as sheet and crepe. The producer will convert his crop into sheet rather than crepe unless the market demand is sufficiently high to allow him to sell crepe at a price which will compensate for the extra expense and trouble involved in its manufacture. Since it is in the form of sheet that the consumer continues to receive the major portion of his raw rubber it is important that the effect on physical properties of any alteration in the preparation or treatment be fully understood. It has been shewn by numerous investigators that considerable variation in the vulcanising properties of plantation sheet does occur, and the influence of the methods of preparation have been extensively studied. An investigation has been started at this Institute to ascertain the effect of the drying conditions on the properties of the sheet rubber, with special reference to recent tendencies towards rapid drying. The results described here are concerned with the ageing properties.

Previous Work

The successive operations which occur in the preparation of sheet rubber may be regarded as stages in a manufacturing process, of which the object is the removal of water from latex, and production of dry rubber in a form easily handled and shipped. The last stage in this process is concerned with the drying of the wet machined sheets. In order that the time required to dry the sheet shall not be unduly prolonged, the sheets are dried at temperatures higher than normal, and usually in some form of smoke-house. Smoke-drying has been used since the very earliest days of the industry and was started as an attempt to imitate the smoke-drying of thin films of latex in the preparation of "Fine Hard

Para" when plantation rubber had not established its market. Its use has persisted, however, and has in fact several advantages, but it is not unreasonable to believe that other methods of drying could be devised which would eliminate entirely the need for smoke.

Considerable quantities of firewood are used in the smoke-drying of sheet rubber. In anticipation of a serious shortage of firewood arising in rubber-producing countries several investigations concerned with the possibility of its elimination in the drying process have been made. Eaton (1) investigated the utilisation of wood in the rubber industry in Malaya in 1924. He considered that it might be possible to substitute unsmoked for smoked sheet since smoking is not advantageous so far as the intrinsic vulcanisation properties of the rubber are concerned. Unsmoked sheet may even be superior when dried at very slightly elevated temperatures. O'Brien (2) considered alternative methods of sheet preparation in Ceylon on account of the serious shortage of firewood which was feared, and prepared a number of samples of sheet air-dried under different conditions, together with corresponding smoked sheet controls. These samples were examined in the laboratories of the London Advisory Committee for Rubber Research. The results showed that the air-dried sheet was invariably inferior in ageing properties to the smoked controls, particularly when dried at temperatures above 90°F. All the air-dried sheet, however, was made from latex to which paranitrophenol had been added to prevent mould development in the dry sheet; it was suggested that this might account for the inferior ageing, and further experiments were made. As a result of these tests O'Brien (3) states that sheet, without paranitrophenol and air-dried at 100°F., has better ageing properties than the smoked sheet controls, whereas that containing paranitrophenol is distinctly inferior. Martin (4) states that, although drying sheet in smoke is a relic of the days when "Fine Hard Para" was more widely used, it does appear to make the rubber more plastic and to prevent mould development. He states, however, that there is no intrinsic difficulty in drying sheet in air at somewhat higher temperatures, that this improves plasticity and decreases mould development, and that air-dried sheet is a comparatively new product, the demand for which is believed to be increasing.

The necessity for the strictest economy in the plantation industry during the recent difficult times has compelled the producer to consider very carefully any alterations or improvements which may reduce costs in the process of preparation. Improved designs for new smoke-houses and attention to ventilation systems, with slight structural alterations in many of the present smoke-houses of the older type, have effected considerable reductions in the time

required to dry sheet rubber. A drying period of four days is now quite common in Malaya and there are few estates today taking 10 days or more to dry their sheet, a period considered quite normal a few years ago. Recent developments have been directed towards reducing the time of drying still more and there are some estates in Malaya equipped with the latest type of driers in which sheet is dried regularly in two days. The temperatures used for rapid drying are of course considerably higher than those used in the smoke-houses of previous days, and in general the sheet is much lighter in colour. The air-dried and smoked sheet prepared by O'Brien (*loc. cit.*) for his ageing comparisons was dried at temperatures lower than those in general use today and was also dried more slowly. In view of this tendency to speed up the drying process it is pertinent to enquire whether the intrinsic properties of the rubber are affected by these alterations in the drying conditions.

Experimental

The accelerated ageing test used in these experiments was the well-known Bierer-Davis oxygen bomb test, in which rings of vulcanised rubber are tested for tensile strength after exposure to oxygen under pressure and at an elevated temperature. The details of the test adopted are given below.

Mixing — The standard mix consists of 20 grams of sulphur and 200 grams of rubber mixed for 20 minutes.

Curing — The mixings are kept for a period of 24 hours after which they are cured in moulds in a steam autoclave at 149°C. using a N.P.L. thermometer to control the temperature.

Time of Cure — The mixings are cured for a time sufficient to give a load of approximately 0.80 kg./sq.mm. at an elongation of 890 per cent. This point represents a period of cure about 20 minutes shorter than the arbitrarily chosen optimum. The cure taken as optimum in these experiments is that which gives a curve passing through the point, elongation 890 per cent, load 1.30 kilograms per square millimetre. As intervals of less than five minutes are not considered in the vulcanisation process the cure adopted for ageing may be sometimes 15, 20 or 25 minutes shorter than the optimum.

Ageing conditions Schopper rings are cut and aged in the bomb at an oxygen pressure of 300 lb. per square inch and a temperature of 60°C, for periods of 24, 48 and 72 hours. All rings are kept for 24 hours at atmospheric temperature after removal from the bomb before they are tested on the Schopper tester. Four rings are broken in each case to obtain an average result for tensile strength at break.

The conditions of oxygen pressure and temperature under which the tests are carried out are those normally used in bomb-ageing work, but the state of cure to which the mixings are taken prior to ageing is an arbitrary one. It was adopted here from a consideration of the results of a number of ageing tests which were made to ascertain at what state of cure differences in the ageing properties of various rubbers could best be distinguished.

It was found that there was considerable difference in the ageing behaviour of rubber from different estates when tested under the conditions described above, and that hot-air-dried sheet did not appear to age so well as smoked sheet.

A comparison was then made of the ageing properties of hot-air-dried and smoked sheet prepared from the same latex in identical manner up to the drying stage. The preparation of the wet sheet was that given to our standard acid controls which are prepared in the following manner: Field latex is diluted to 1¼lb. per gallon dry rubber content and coagulated in pans with 1 per cent formic acid at the rate of 7½ fluid ounces per gallon of latex. The coagulum is machined the following morning and passes through the machines five times, four times through the smooth and once through the marking rolls. It is then soaked in running water for two hours, drained for two hours and dried. The air-dried sheet was dried in an electrically-heated, thermostatically-controlled drying cabinet and the smoked sheet was dried in a neighbouring estate smoke-house. The time of drying was three and four days at temperatures of 120° — 130° F. and 120° — 140°F. respectively. The ageing figures are given in Table I.

The rate of deterioration of the air-dried sheet is greater than that of the smoked sheet. Similar results were obtained when other direct comparisons were made with sheet dried in hot air and in smoke.

An experiment was then carried out in which sheet was made from the same crop of latex, diluted to different dry rubber contents before coagulation, and the sheet dried in the hot-air cabinet and the estate smoke-house as before. The preparation of the sheet, prior to the drying stage, from the latex diluted to various strengths was that adopted as standard for the particular D.R.C.

TABLE I

Smoked and Air-Dried Standard Control Sheet

Vulcanised rings aged in oxygen at 300 lb./sq. inch pressure
Temperature 60°C.

Sample.	Time of Cure to give 1.30 kg./sq.mm. at an Elongation of 890% min.	Ageing Cure min.	Tensile Strength at break after ageing for hours :— k.g./sq.mm. 0	24	48	72
Hot Air-dried Sheet	102	80	1.26	1.26	0.79	0.06
Smoked Sheet	104	85	1.13	1.27	1.26	1.24

and differs only from that given to standard sheet in the quantity of acid used and number of machinings given to the coagulum. The ageing results of the sheet are given in Table II.

TABLE II

Sheet prepared under Standard Conditions

Vulcanised rings aged in oxygen at 300 lb./sq. inch pressure
Temperature 60°C.

Sample No.	D.R.C. lb. per gallon	Air-dried Sheet or Smoked Sheet	Time of Cure to give 1.30 kg./sq.mm. at an Elongation of 890% min.	Ageing Cure min.	Tension Strength at break after ageing for hours:— kg./sq.mm. 0	24	48	72
L 194/1/1	2½	Air-dried Sheet	98	75	1.28	1.48	1.28	0.35
L 195/1/1	1½	„	109	95	1.34	1.34	0.15	0.03
L 196/1/1	½	„	103	85	1.48	1.34	0.79	0.07
L 194/1/2	2½	Smoked Sheet	108	90	1.29	1.38	1.24	1.13
L 195/1/2	1½	„	109	95	1.30	1.49	1.31	1.15
L 196/1/2	½	„	125	105	1.32	1.34	1.28	0.57

The smoked sheet prepared from latex coagulated at all three dry rubber contents ages better than the corresponding air-dried sheet. That prepared from latex of low D.R.C., however, does not appear to retain its tensile strength so well as that prepared from the latex of higher D.R.C.

Air-dried and smoked sheet was also prepared from the same latex diluted similarly, but from coagulum which was soaked for 24 hours before machining. The ageing figures given in Table III again show the smoked sheet to age better than the air-dried sheet.

TABLE III

Sheet prepared from Coagulum soaked for 24 hours before machining

Vulcanised rings aged in oxygen at 300 lb./sq. inch pressure Temperature 60°C.

Sample No.	D.R.C. lb. per gallon	Air-dried Sheet or Smoked Sheet	Time of Cure to give 1.30 kg./sq.mm. at an Elongation of 890% min.	Ageing Cure min.	Tensile Strength at break after ageing for hours:— kg./sq.mm. 0	24	48	72
L 194/1/3	2½	Air-dried Sheet	101	85	1.41	1.34	0.86	0.06
L 195/1/3	1½	„	106	90	1.34	1.34	0.80	0.06
L 196/1/3	½	„	110	90	1.43	1.19	0.08	0.05
L 194/1/4	2½	Smoked Sheet	95	95	1.27	1.45	1.32	1.01
L 195/1/4	1½	„	90	90	1.21	1.36	1.28	1.18
L 196/1/4	½	„	105	105	1.36	1.45	1.08	0.13

In connection with other experiments, further samples of air-dried and smoked sheet were made from this same bulk of latex under similar conditions, except for the amount of acid used for coagulation, which was 50 per cent more than normal. Ageing tests were carried out and the results for sheet made under normal conditions and after the coagulum had soaked for 24 hours are given in Tables IV and V.

The figures given in Tables II, III, IV and V are shown graphically in figures 1, 2 and 3 in which the preparation treatments for each D.R.C. at which coagulation was made are brought together. The smoked sheet is superior to the air-dried sheet in all experiments in which the rubber is prepared from latex of

TABLE IV

Sheet prepared from Latex coagulated with Excess Acid

Vulcanised rings aged in oxygen at 300 lb./sq. inch pressure
Temperature 60°C.

Sample No.	D.R.C.	Air-dried Sheet or Smoked Sheet	Time of Cure to give 1.30 kg./sq.mm. at an Elongation of 890%	Ageing Cure	Tensile Strength at break after ageing for hours :— kg./sq.mm.			
	lb. per gallon		min.	min.	0	24	48	72
L 194/2/1	2½	Air-dried Sheet	112	90	1.30	1.35	1.16	0.10
L 195/2/1	1½	„	113	90	1.31	1.36	1.08	0.09
L 196/2/1	½	„	117	95	1.35	1.25	0.48	0.05
L 194/2/2	2½	Smoked Sheet	116	95	1.31	1.44	1.38	1.24
L 195/2/2	1½	„	117	100	1.36	1.48	1.32	1.04
L 196/2/2	½	„	124	105	1.39	1.31	0.97	0.08

TABLE V

Sheet prepared from Latex coagulated with Excess Acid, Coagulum soaked 24 hours before machining

Vulcanised rings aged in oxygen at 300 lb./sq. inch pressure
Temperature 60°C.

Sample No.	D.R.C.	Air-dried Sheet or Smoked Sheet	Time of Cure to give 1.30 kg./sq.mm. at an Elongation of 890%	Ageing Cure	Tensile Strength at break after ageing for hours :— kg./sq.mm.			
	lb. per gallon		min.	min.	0	24	48	72
L 194/2/3	2½	Air-dried Sheet	111	90	1.48	1.42	0.80	0.06
L 195/2/3	1½	„	114	95	1.34	1.22	0.61	0.07
L 196/2/3	½	„	118	100	1.34	1.36	0.07	0.05
L 194/2/4	2½	Smoked Sheet	119	100	1.44	1.42	1.35	1.09
L 195/2/4	1½	„	119	100	1.24	1.26	1.12	0.88
L 196/2/4	½	„	126	105	1.32	1.43	1.24	1.20

D.R.C. 2½ and 1½ lb. per gallon. With very dilute latex of ½ lb. per gallon D.R.C., the smoked sheet is not superior in all cases, although the rate of deterioration is not quite so fast as for the corresponding air-dried samples.

Sheet dried in Estate Smoke-houses

An experiment was made to ascertain whether sheet prepared and hot-air-dried at the Institute, was inferior to that prepared at the Institute and dried in estate smoke-houses other than the particular house used for the smoke-drying of the sheet tested in the previous experiments. A number of standard control wet sheets were prepared at the Institute from the same crop. Some were hot-air-dried and some taken to a number of estates where they were dried in the estate smoke-houses by kind permission of the managers. There was considerable variation in the type of smoke-house in which these sheets were dried and the dry rubber differed in colour from house to house. The details concerned with the drying of these sheets are given in Table VI and the ageing figures in Table VII and figure 4.

TABLE VI

Details of Drying Conditions

Sample No.	Air-dried Sheet or Smoked Sheet	Where dried	Time of drying hours	Temperature of drying °F.	Colour of dry Sheet
L 251/1	Air-dried Sheet	R. R. I.	92	120 – 130	Light yellow
/2	Smoked Sheet	Estate A	144	„	Brown
/3	„	„ B	64	„	Blue black
/4	„	„ C	92	120 – 140	Brown
/5	„	„ D	72	130 – 140	Brown
/6	„	„ E	43	130 – 145	Orange brown
/7	„	„ F	264	130	Light orange

As was expected, the air-dried sheet shows poor ageing figures, but it is also noted that the rubber dried in the different smoke-houses varies in its ageing resistance. As a rough classification it may be said that these sheets fall into two groups having good and poor ageing properties. The sheet dried on Estates A, B and C has good ageing properties while that from D, E and F has inferior ageing properties, Estate F being particularly poor.

TABLE VII

Standard Sheet dried in different Smoke-houses

Vulcanised rings aged in oxygen at 300 lb./sq. inch pressure Temperature 60°C.

Sample No.	Air-dried Sheet or Smoked Sheet	Where dried	Time of Cure to give load of 1.30 kg./sq.mm at Elongation of 890% min.	Ageing Cure min.	Tensile Strength at break after ageing for hours :— kg./sq.mm.			
					0	24	48	72
L 251/1	Air-dried Sheet	R. R. I.	115	95	1.25	1.28	0.34	0.05
/2	Smoked Sheet	Estate A	120	100	1.23	1.19	1.33	0.99
/3	„	„ B	126	105	1.24	1.43	1.31	1.34
/4	„	„ C	120	100	1.41	1.25	1 29	1.20
/5	„	„ D	118	100	1.28	1 33	1.23	0.63
/6	„	„ E	124	100	1.31	1.45	1.26	0.14
/7	„	„ F	115	95	1.27	1.25	0.09	0.05

Discussion

Apart from the figures in Table VII, which are discussed separately, the results indicate that sheet dried in hot air, in a time commensurate with modern drying practice, is invariably inferior in ageing properties to that dried in smoke, unless the latex be diluted to a low D.R.C. before coagulation. Since in these experiments the sheet was made from the same latex and in identical manner up to the drying stage it is evident that the process of smoking improves the ageing properties. It may be argued that the results in Table VII are not in accordance with this conclusion. An examination of Table VI giving the conditions under which the sheet was dried is of considerable interest in this connection and an explanation of the anomalies is suggested. Estates A, B and C which produce sheet with satisfactory ageing properties have smoke-houses which are of the older type but dry rubber in a reasonable time. The sheet dried in these houses is of brown colour, that dried on Estate B being particularly dark. Estates D and E, which fall into the group giving inferior ageing, have rapid-drying houses of a patented design, and sheet dried in these houses is not dried in smoke through the whole drying period.

Their construction is such that after an initial period of smoke-drying the operation is finished in a hot-air chamber without smoke at a more elevated temperature. Estate F, which gives sheet with ageing figures inferior even to those for sheet dried in hot air, has an old type of smoke-house but it will be observed that the time of drying is much longer than any of the other estates. On inquiry into the reason for this it was found that the sheet was actually dry in a shorter time but the colour was so light that it was left in the smoke-house for some longer time to darken. It was still, however, very light even after 11 days drying. The possibilities of impairing the ageing properties by prolonged heating are at once apparent.

Until more information is available on a number of points which are now under investigation it is not proposed to suggest any explanation for the differences in ageing properties between hot-air-dried and smoked sheet. Experiments concerned with the effects of different preparation treatments at different dilutions, in conjunction with variations in time and temperature of drying are in progress. Further experiments concerned with the humidity at which drying takes place and time during which the sheet is in an atmosphere of smoke will give information from which more definite conclusions on the effect of the drying conditions on the ageing properties may be drawn.

Summary

An examination of sheet rubber prepared in identical manner up to the drying stage shows that hot-air-dried sheet and smoked sheet have different ageing properties.

Hot-air-dried sheet is invariably inferior to smoked sheet except when prepared from very dilute latex. Further work is required before any explanation is offered.

Acknowledgement

The preliminary work of my late colleague, Dr. Wiltshire, on the ageing properties of clonal and estate rubber led him to express the opinion that it was impossible to compare the ageing properties unless the details of preparation were known and that they would most likely determine the ageing properties. The work described in this paper developed from these ideas and grateful acknowledgement is made.

Thanks are due to the managers of the various estates who kindly co-operated in the drying experiments, and particularly to the manager of Kepong Estate who has so kindly permitted us to use his factory on many occasions.

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Kuala Lumpur,

5th December, 1935

FIGURE 1

SHEET FROM LATEX OF D.R.C. 2½ lb. PER GALLON

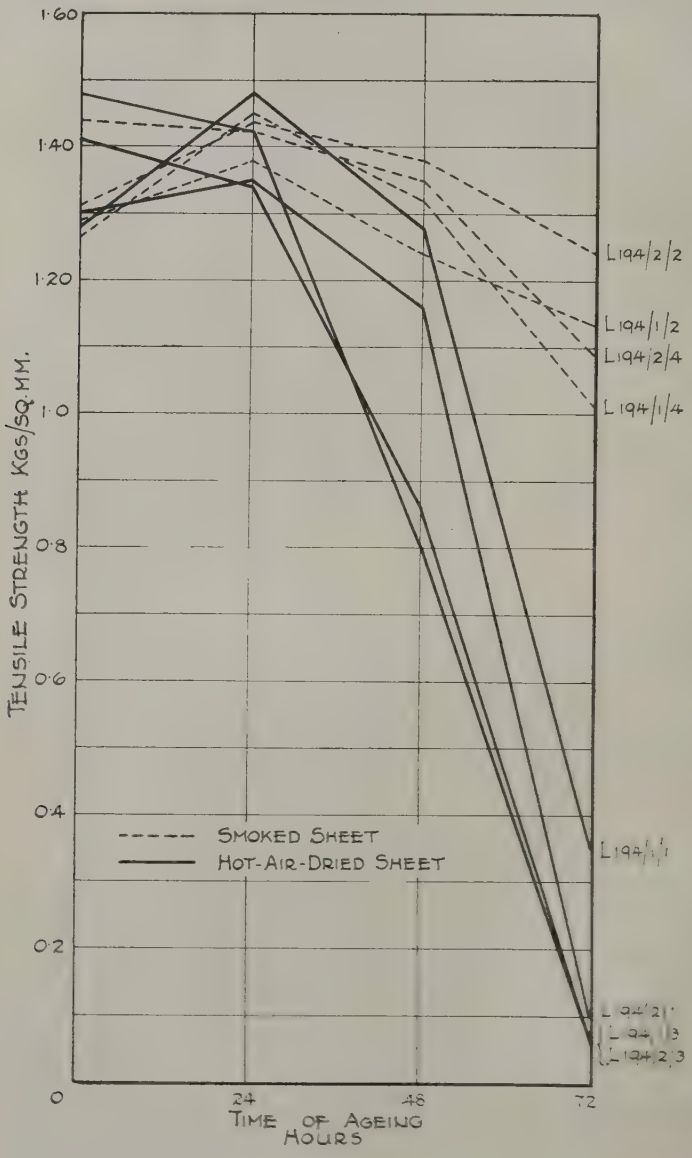


FIGURE 2

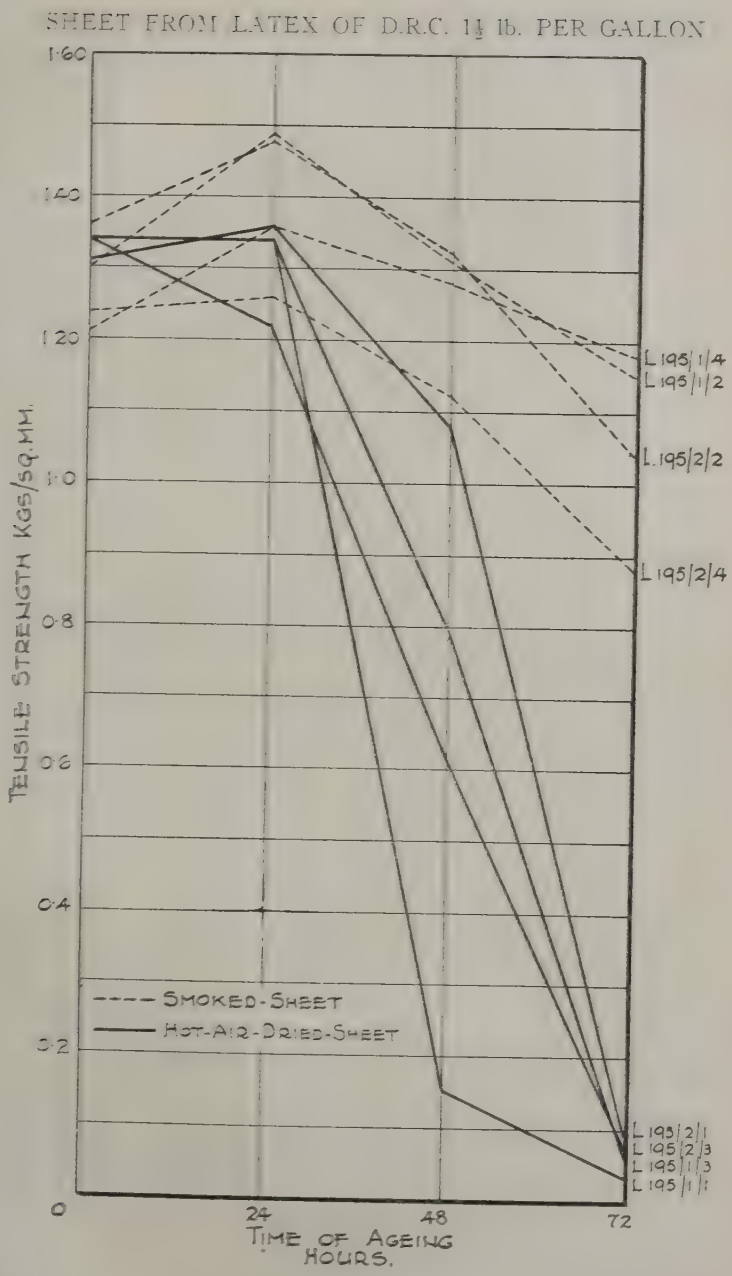

SHEET FROM LATEX OF D.R.C. 1½ lb. PER GALLON
1·60
1·40
1·20
1·0
0·8
0·6
0·4
0·2
0
TENSILE STRENGTH KGS/SQ.MM.
24
48
72
TIME OF AGEING HOURS.
---- SMOKED-SHEET
—— HOT-AIR-DRIED-SHEET
L 195/1/4
L 195/1/2
L 195/2/2
L 195/2/4
L 195/2/1
L 195/2/3
L 195/1/3
L 195/1/1

FIGURE 3

SHEET FROM LATEX OF D.R.C. ½ lb. PER GALLON

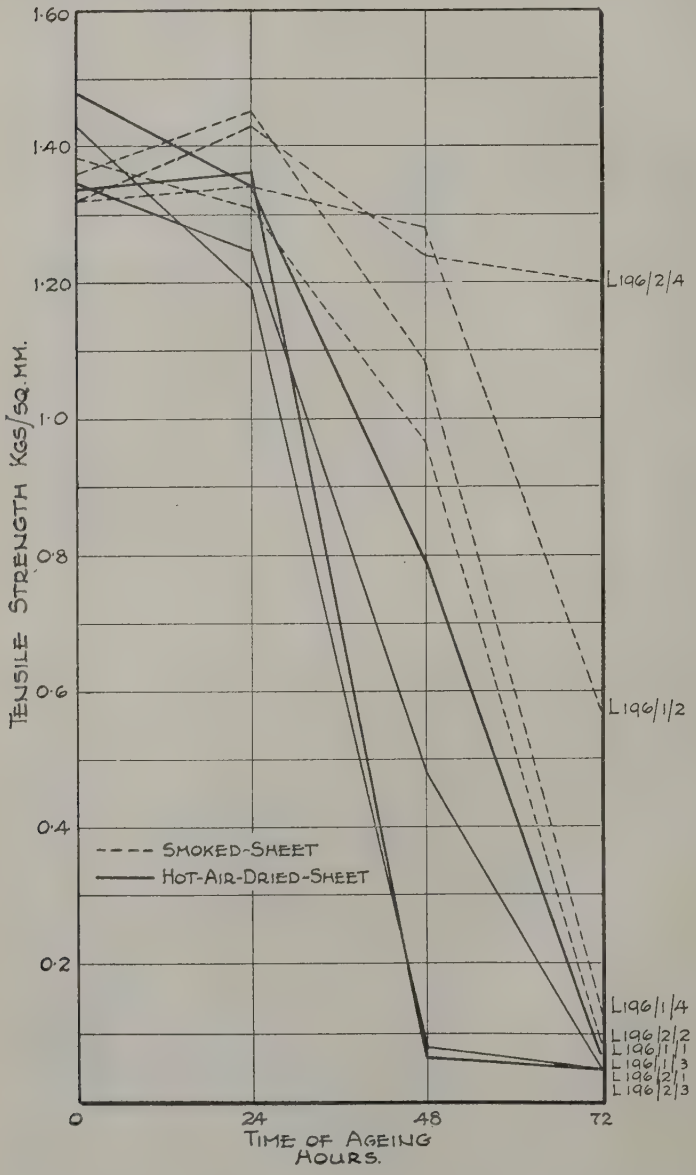
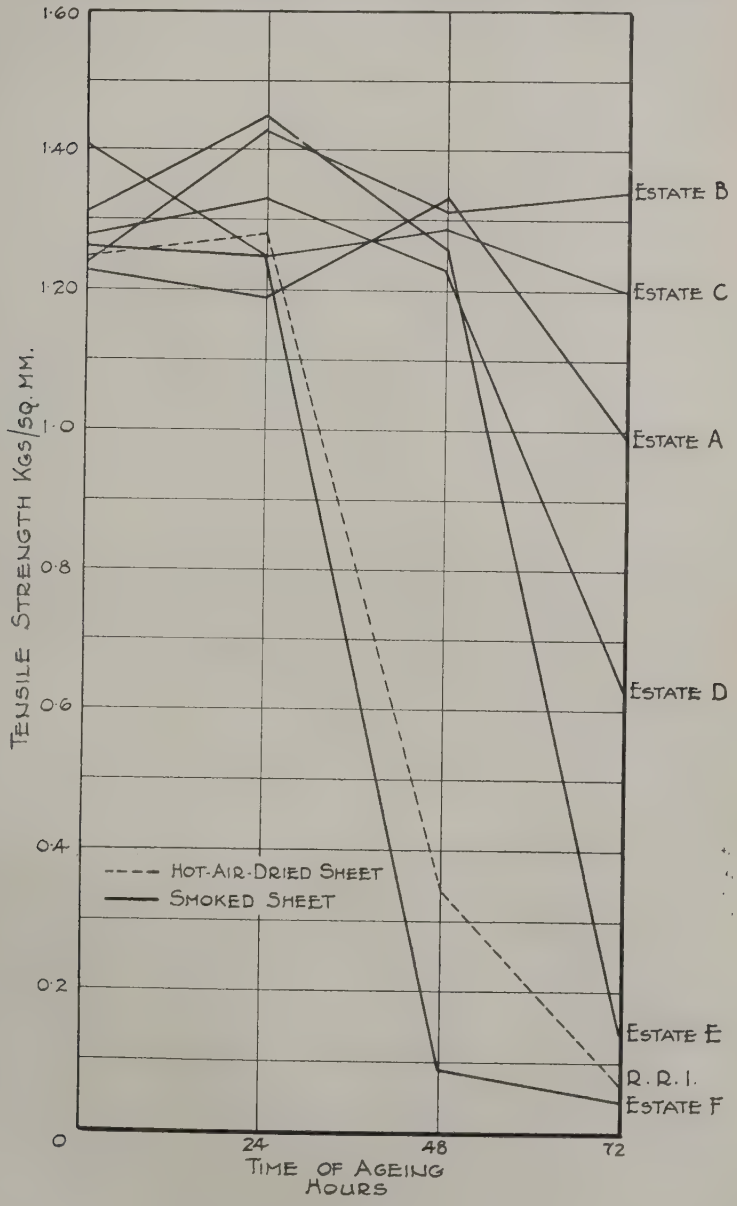


FIGURE 4

STANDARD SHEET DRIED IN ESTATE SMOKE-HOUSES



EXPERIMENTS WITH ECONOMIC TAPPING SYSTEMS (1)

BY

C. C. T. SHARP

Part III

Results of tapping for the second Year, June 1934—May 1935 of the Experiment on Seventh Mile Estate

A description of the experiment and the results obtained from the first year's tapping have appeared in Vol. 5, No. 4 of this *Journal*.

The records kept during the first year have been continued during the second year of the experiment and the results are set out in Tables XI to XV and Figure 3.

TABLE XI

Yields June 1934—May 1935

Total Yield per Plot (lb. dry Rubber) excluding Scrap

Block	Plots and Tapping Systems							
	1	2	3	4	5	6	7	8
	A.B.C. 6-3	A.B.C. 10-5	A.B.C. 14-7	Sunderland 3-3	Sunderland 5 5	Sunderland 7-7	Double-four	Alternate-daily
I	2,570.7	2,818.7	2,430.6	1,786.1	2,121.5	1,992.4	5,677.5	1,965.0
II	2,711.2	2,353.6	2,368.9	1,520.9	1,581.0	1,685.4	5,145.0	1,963.7
III	2,599.6	2,581.9	2,594.7	1,461.0	2,107.4	1,506.0	5,010.0	1,865.7
IV	2,757.6	3,210.0	2,833.4	1,750.8	2,046.8	1,730.5	5,764.9	2,512.8
V	2,966.4	2,675.7	2,888.0	2,009.0	1,551.0	1,654.2	5,604.4	1,928.9
VI	2,389.4	2,200.6	2,131.0	1,632.1	1,735.9	1,676.1	4,795.9	2,218.2
	15,994.9	15,840.5	15,246.6	10,159.9	11,143.6	10,244.6	31,997.7	12,454.3

Grand Total = 123,082.1 lb

TABLE XII

Yield in lb. per Acre for second Year of Tapping of first-grade Rubber, Scrap Rubber and total dry Rubber

	Block	Plots and Tapping System							
		1 A.B.C. 6-3	2 A.B.C. 10-5	3 A.B.C. 14-7	4 Sunderland 3-3	5 Sunderland 5-5	6 Sunderland 7-7	7 Double-four	8 Alternate-Daily
First-grade Rubber	I	479.9	526.2	453.7	416.8	495.0	464.9	662.4	550.2
	II	506.1	439.3	442.2	354.9	368.9	393.3	600.3	549.8
	III	485.3	482.0	484.3	340.9	491.7	351.4	584.5	522.4
	IV	514.8	599.2	528.9	408.5	477.6	493.8	672.6	703.6
	V	553.7	499.5	539.1	468.8	361.9	386.0	653.8	540.1
	VI	446.0	410.8	397.8	380.8	405.0	391.1	559.5	621.1
	Mean	497.6	492.8	474.3	395.1	433.4	398.4	622.2	581.2
	Per cent.	85.6	84.8	81.6	68.0	74.6	68.4	107.1	100.0
Scrap	Mean	55.8	55.0	52.8	64.3	74.5	66.0	112.9	77.6
	Per cent. of First-Grade	11.2	11.2	11.1	16.3	17.2	16.6	18.1	13.4
Total Dry Rubber	Mean	553.4	547.8	527.1	459.4	507.9	464.4	735.1	658.8
	Per cent.	84.0	83.2	80.0	69.7	77.1	70.5	111.6	100.0

General mean = 486.9 lb. first-grade rubber per acre

The yield of the control plots shows a fall of 7 per cent below the yield of the previous year, and that of the double-four plots of 6 per cent. That part of this fall is due to the change from virgin bark to renewed bark is probable. Whether there is a general falling off in yield is therefore uncertain. However that may be, the response to rest in the form of increased yields of the other six tapping systems is more than sufficient to offset this loss and the whole area shows an increase of 2 per cent.

Table XII is in continuation of Table VI in Part II of the description of this experiment (*Journal* Vol. 5 No. 4).

In Table XIII the mean yield per acre of first-grade rubber is shown in lb. per acre and as a percentage of the control for each month of the second year of the experiment. The columns showing

TABLE XIV

Analysis of Variance. First-Grade Rubber

	Degrees of Freedom	Sums of Squares	Mean Squares
Treatments ...	7	528865.2	75552.2
Blocks ...	5	84077.6	16815.5
Error ...	35	79332.4	2266.6

TABLE XV

Yield per Tapper and Comparative Cost of Tapping (2nd Year)

Tapping System	Yield per Tapper per Tapping			Comparative cost per lb.		Comparative Yield per acre	
	First grade rubber lb.	Scrap rubber lb.	Total dry rubber lb.	First grade rubber per cent	Total dry rubber per cent	First grade rubber per cent	Total dry rubber per cent
1	15.9	1.8	17.5	78.0	79.3	85.6	84.0
2	15.8	1.8	17.6	78.5	79.7	84.8	83.2
3	15.1	1.7	16.8	82.1	83.5	81.6	80.0
4	15.1	2.4	17.5	82.1	80.9	68.0	69.7
5	16.6	2.9	19.5	74.7	72.8	74.6	77.1
6	15.4	2.6	18.0	80.5	78.8	68.4	70.5
7	15.9	2.9	18.8	78.0	75.7	107.1	111.6
8	12.4	1.7	14.1	100.0	100.0	100.0	100.0

TABLE XIII

Mean Yield in lb. per acre per month, of First-Grade Rubber

(Second Year of Experiment)

	Plots and Tapping Systems																					
	1 A. B. C. 6–3			2 A. B. C. 10–5			3 A. B. C. 14–7			4 Sunderland 3–3			5 Sunderland 5–5			6 Sunderland 7–7			7 Double-four			8 Alternate-Daily		
	Yield			Yield			Yield			Yield			Yield			Yield			Yield			Yield		
	lb.	per cent	Total per cent	lb.	per cent	Total per cent	lb.	per cent	Total per cent	lb.	per cent	Total per cent	lb.	per cent	Total per cent	lb.	per cent	Total per cent	lb.	per cent	Total per cent	lb.	per cent	Total per cent
June 1934	40.9	83.6	75.9	42.9	87.7	74.4	41.0	83.8	70.8	26.0	53.1	58.7	43.1	88.1	66.3	33.6	68.8	58.9	60.0	122.7	107.2	48.9	100.0	100.0
July „	38.9	86.8	76.6	38.6	86.2	75.1	35.8	79.9	71.4	32.6	72.8	59.6	34.4	76.8	66.9	35.9	80.1	60.2	54.9	122.5	108.1	44.8	100.0	100.0
August „	37.9	82.0	77.0	38.5	83.3	75.6	36.5	79.0	71.8	35.0	75.8	60.5	34.4	74.5	67.4	25.3	54.8	59.9	52.8	114.3	108.5	46.2	100.0	100.0
September „	38.8	75.5	76.9	42.3	82.3	76.0	43.5	84.6	72.6	25.4	49.4	59.8	24.5	47.7	66.1	35.0	68.1	60.4	59.0	114.8	108.9	51.4	100.0	100.0
October „	46.8	97.1	78.0	43.6	90.5	76.9	42.7	88.6	73.5	38.2	79.3	60.9	38.9	80.7	67.0	35.9	74.5	61.2	51.6	107.1	108.8	48.2	100.0	100.0
November „	41.9	85.3	78.4	42.9	87.4	77.4	37.8	77.0	73.7	32.2	65.6	61.2	39.1	79.6	67.6	35.5	72.3	61.8	47.9	97.5	108.2	49.1	100.0	100.0
December „	44.5	77.9	78.4	47.2	82.7	77.7	41.7	73.0	73.8	28.7	50.3	60.1	39.8	69.7	67.8	35.0	61.3	61.8	57.0	99.8	107.7	57.1	100.0	100.0
January 1935	46.8	93.4	79.1	41.5	82.8	78.0	39.3	78.4	73.9	43.1	86.0	61.8	34.6	69.1	67.8	31.3	62.5	61.8	48.8	97.4	107.2	50.1	100.0	100.0
February „	37.5	81.0	79.2	35.8	77.3	77.9	34.0	73.4	73.9	32.0	69.1	62.1	23.0	49.7	67.0	27.7	59.8	61.7	43.7	94.3	106.6	46.3	100.0	100.0
March „	42.4	95.9	79.8	42.2	95.4	78.6	40.4	91.4	74 6	25.5	57.7	61.9	44.1	99.8	68.4	29.2	66.1	61.9	48.6	110.0	106.8	44.2	100.0	100.0
April „	41.9	91.1	80.3	38.6	83.9	78.8	42.9	95.3	75.3	40.8	88.7	63.0	36.5	79.3	68.8	38.8	84.3	62.8	49.6	107.8	106.8	46.0	100.0	100.0
May „	39.5	80.3	80.3	38.9	79.1	78.9	38.8	78.9	75.5	34.0	69.1	63.3	40.9	83.1	69.5	35.3	71.7	63.1	48.5	98.6	106.5	49.2	100.0	100.0

NOTE :—The thick horizontal lines indicate the point at which a rested section is brought into tapping and a tapped section taken into rest.

" Total per cent " are in continuation of the corresponding columns in Table VII in Part II of the account of this experiment (*loc. cit.*) and show the total yield from the commencement of the experiment up to the end of each month as a percentage of the total yield of the control for the same period. The curves for the total yield are also shown graphically in Figure 3 below.

The standard error of the difference between two means of six plots is 25.6 lb. or 5.26 per cent. This shows a very small reduction from the error found during the first year. Differences of less than 10.5 per cent cannot be regarded as significant.

In calculating the cost of tapping the procedure adopted in computing the first year's results has been repeated. To compensate for the difference in value of first-grade rubber and scrap rubber the total weight of dry rubber is assumed to be the weight of the first-grade rubber plus three-quarters of the weight of the scrap rubber. Compared with the control there is a considerable saving in tapping costs in all the systems under test.

TABLE XVI

Mean Dry Rubber Content

Month	Tapping Systems							
	1	2	3	4	5	6	7	8
June 1934	41.5	39.5	38.9	47.5	39.4	40.5	40.5	40.0
July	41.3	39.4	40.4	43.2	38.6	40.9	40.7	41.4
August	41.9	39.1	43.2	40.6	37.7	48.4	39.9	39.9
September	42.0	42.1	39.7	46.4	47.1	41.2	40.7	40.8
October	40.6	40.4	39.0	41.8	42.2	40.6	39.6	41.4
November	41.2	40.3	40.7	41.4	40.4	39.6	40.3	41.0
December	43.0	40.2	40.4	46.8	39.1	39.1	41.3	41.1
January 1935	42.1	41.0	40.6	43.0	40.2	40.9	41.6	42.2
February	40.9	43.0	40.5	40.4	47.8	39.5	40.4	41.6
March	42.4	41.2	42.1	46.0	41.3	46.5	40.0	40.3
April	39.8	39.0	38.7	40.8	38.7	40.9	39.6	38.8
May	38.7	38.4	38.3	40.2	38.2	39.6	39.7	39.9

The horizontal lines show the points at which tapping and rested sections were changed over.

Discussion

A. B. C. Tapping. Plots 1, 2, 3.

The yields from A.B.C. tapping have increased by 10.2, 11.4 and 11.8 per cent respectively. The slight difference in favour of the shortest rest periods noticed at the end of the first year has been reduced. The differences in yield are without significance. The loss in crop (first-grade rubber only) during the second year amounts on the average for the three plots to 16 per cent and the saving in tapping costs to 20.5 per cent. For the whole period of two years the loss of crop is 21.8 and the saving in tapping costs 14.7 per cent.

Sunderland Tapping. Plots 4, 5 and 6.

The yields of first-grade rubber for the second year have increased to 64.3, 74.5 and 66.0 per cent from 59.1, 64.6 and 58.1 respectively. Plot 5, with tapping and resting periods of five months, is now significantly better than Plot 4 with tapping and resting periods of three months, and very possibly better than Plot 6 with resting and tapping periods of seven months.

Plot 5, the best of the three Sunderland systems, is still inferior to Plot 1, the best of the three A.B.C. systems in point of yield. On the other hand the saving in tapping costs is 27.2 per cent as against 20.7 per cent in Plot 1. This shows a considerable improvement over the first year's results. A comparison of the yields and tapping costs over the whole period of two years of Plots 1 and 5 shows that the yields are in the proportion of 80.3 to 69.5 and the tapping costs in the proportion of 82.9 to 80.3. The saving in tapping costs is small compared with the greater loss in crop in Plot 5. On the whole the balance is still in favour of the A.B.C. system.

The Double-four System. Plot 7.

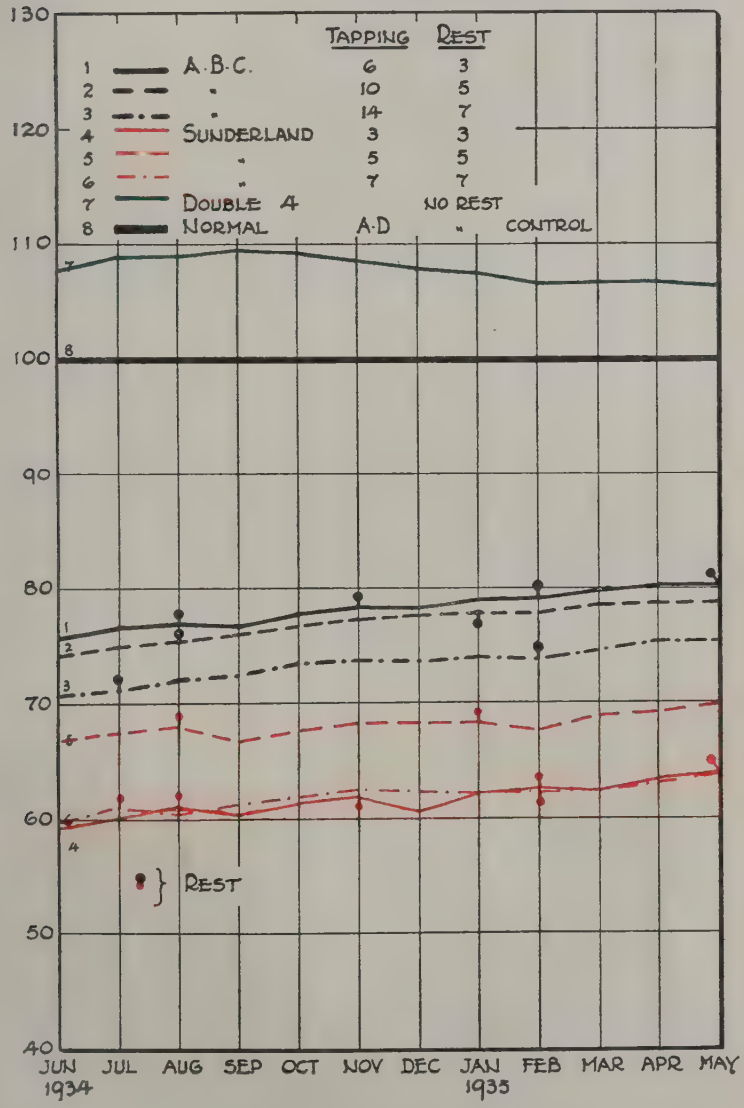
The results of the second year's tapping correspond very closely to those of the first year. The yield of the second year is 107.1 per cent of the control compared with 105.9 in the first year, and the cost of tapping 78.0 per cent as against 78.2 per cent for first-grade rubber. If scrap rubber is included the figures would be 113 and 111.6, and 74.7 and 75.7 in the first and second years respectively.

Bark Consumption

Changing the tappers from one task to another every 24 days, a necessity in an experiment of this type, has rendered the control of bark consumption more difficult than it would be under ordinary

TAPPING EXPERIMENT ON 7th MILE ESTATE

PROGRESS OF TOTAL YIELD AS PERCENTAGE OF CONTROL
2nd YEAR



estate conditions. But quite apart from this difficulty it has been found by experience that the drying of the tapping cut is so much greater with fourth-daily tapping than with alternate-daily tapping that a total bark consumption of 9 inches per annum cannot be maintained with the double-four system, the average for the two years being at the rate of 11 inches per annum.

In consequence of this unavoidable increase in bark consumption it has been found necessary to convert the double-four system to a double-four A.B.C.D. system, starting from 1st October, 1935, after the completion of 28 months' tapping. It has been decided to rest each section of Plot 7 in turn for a period of four months while the remaining three sections are tapped as before on every fourth day.

Kuala Lumpur,

1st December, 1935

USE OF WEED-KILLERS IN THE CONTROL OF NATURAL COVERS

BY

C. G. Akhurst

Weed-killers have been used for a considerable number of years in agricultural practice; in Europe and America quite extensive use of them is made nowadays, particularly for improving cereal crops. Spraying is the usual means of applying the weedicide and the substances used include iron sulphate, copper sulphate, sodium chlorate, sulphuric acid, nitric acid and calcium cyanamide. The improvement of lawns and areas of grass by this means has received considerable attention and satisfactory results have been obtained.

The development of natural covers on rubber estates in Malaya has created an interest in the use of chemicals as a means of controlling and eradicating certain types of covers, particularly where, through inadequate attention and control, bracken *(Gleichenia linearis)* and stagmoss *(Lycopodium cernuum)* have developed in dense masses.

Ordinary slashing of these thick growths is expensive, and does not completely eradicate them, further treatment being necessary after a few months. Obviously, a chemical which, when sprayed on the plants, will completely kill them is highly desirable from several points of view. Cost of eradication will be reduced, damage to rubber roots by "changkols", etc., will be eliminated and, as no soil disturbance will take place, the risk of erosion will be greatly reduced.

Only two types of weed-killers have been tried to any extent on rubber estates, one being a compound in which sodium chlorate is the effective agent and the other a liquid containing arsenic (sodium arsenite) as the destructive substance.

The sodium chlorate is marketed in the solid form and is applied in the form of a 2.5 per cent solution in water. About 25 gallons of the solution are required per acre. Spraying is carried out in some suitable form of sprayer such as the "Four-Oaks" knapsack sprayer; one labourer can effectively treat one acre per day.

The arsenical weed-killer is sold in a concentrated liquid form, the solution being alkaline and containing in addition tarry matter. For use, this liquid is diluted 20 times, and is applied at a similar rate as for sodium chlorate.

About thirty estates, to our knowledge, have made use of weed-killers within the last two years and detailed reports have been received from about one-third.

Records of Results

ESTATE A

Thick growths of grass, *(Axonopus compressus)* were treated respectively with sodium chlorate and with ordinary anti-malarial oil. A 2 per cent solution of the sodium chlorate was sprayed at the rate of 100 gallons per acre, the material alone costing $4.00 per acre and labour an additional 50 cents. Weather conditions were not particularly dry and the result was a scorching of the tops, with no permanent effect on the grass.

With anti-malarial oil, 40 gallons per acre were used, costing with labour $9.00 per acre, and the above-ground shoots were all killed, but the grass was not destroyed.

ESTATE B

Lalang grass, carpet grass *(Axonopus compressus)* and cattle grass or "sani pillu" *(Paspalum conjugatum)*, were all treated with arsenic weed-killer under good weather conditions. A dilution of one part in 20 parts of water was applied at the rate of between 80 and 100 gallons per acre. The lalang grass was effectively killed above ground, but within three weeks was shooting again vigorously. The other two types of grasses were burned off, but were sending up new shoots after ten days, and after three weeks were as thick as before.

The cost of this treatment was about $9.00 per acre.

ESTATE C

Areas of cattle grass ("sani pillu"), about one foot high, were treated with different concentrations of arsenic weed-killer. The normal strength solution (1 in 20), and solutions of twice and thrice this strength were used, at the rate of 20 gallons per acre. Where the "1 in 20" strength was used, second and third applications were made as soon as new grass shoots began to appear. In each instance a successful burning of the grass tops was obtained but no complete killing of the roots occurred. With twice the normal strength of spray, regeneration of the grasses was complete in two months. The costs were $4.50, $6.50 and $7.00 per acre, respectively.

A little stagmoss which was growing amongst the grasses was completely killed in every case, and some wild "coffee" plants

(Fagraea racemosa) were only slightly affected, their leaves being scorched.

A modification of this experiment is in progress, where, after killing the grass tops with one spraying of normal strength, the roots will be exposed by a light "changkolling" and will be sprayed once.

Estate D

A small area of lalang grass was treated with sodium chlorate (2 per cent solution) three sprayings being given at 10-day intervals. Following this, the very much weaker shoots were hand-pulled and then, at 4-monthly intervals, spraying and hand-pulling were repeated. This resulted in the disappearance of the lalang after 18 months.

Heavy lalang grass was also killed in three to four months by successive sprayings with large volumes of 2 per cent chlorate solution, but the cost of eradication amounted to about $300 per acre.

Estate E

Areas of dense lalang grass were sprayed with sodium chlorate solutions, at strengths varying from normal to four times the normal strength, two or three sprayings being made in each case. The total amounts of sodium chlorate used per acre ranged from 6 lb. up to 20 lb. Again, complete destruction above ground was achieved, but new shoots soon appeared from the uninjured root systems.

Costs varied from $1.40 to $4.30 per acre.

Estate F

On this estate a variety of chemicals in solid and liquid form were applied to areas on which stagmoss was the principal natural cover, other growths including Straits rhododendron, lalang, other grasses, rubber seedlings, and desirable types of natural covers.

The chemicals applied included iron sulphate, double kainit (potassium, magnesium sulphate and magnesium chloride), ordinary salt, copper sulphate, lime, Adco, and sodium chlorate.

Most of the compounds had very little effect, and those that did kill the stagmoss were too expensive, *e.g.* copper sulphate killed stagmoss at a cost of $5.00 per acre. The only exception was sodium chlorate which destroyed the above-ground portions of the stagmoss at a cost of about $1.00 per acre.

ESTATE G

Areas of bracken *(Gleichenia linearis)* and carpet grass *(Axonopus compressus)* were treated with arsenic weed-killer at three dilutions, *viz.*, normal, ⅔ normal and ½ normal strength. In the first series of tests rain followed the spraying within two hours, and no results were obtained. In dry weather, a repetition of the experiment produced a satisfactory killing of bracken with all three dilutions, while several desirable types of natural covers remained alive and had only their leaves damaged. The treatment of the grass caused the usual scorching of the grass blades, but within three weeks new and vigorous shoots were appearing.

ESTATE H

Moderately dense growths of stagmoss were sprayed with arsenic weed-killer under ideal weather conditions. One round of spraying, using 20 gallons of a 1 in 20 solution per acre, was carried out, and this was followed by a second spraying, using 15 gallons of a 1 in 30 dilution. Effective killing of the tops resulted, but the root systems were only partially killed.

The cost of this spraying was $5.00 per acre.

ESTATE K

Areas of stagmoss and bracken were sprayed with arsenic weed-killer, using 20 to 25 gallons of a 1 in 20 dilution per acre. The treatment, which was carried out in dry weather, resulted in the killing of both bracken and stagmoss; a small amount of hand-pulling was needed some two or three months later in order to complete the eradication.

ESTATE L

On this estate heavy bracken areas were sprayed with normal dilutions of arsenic weed-killer, using 20 to 25 gallons per acre, the spray being applied in the middle of the day. The bracken was completely killed, and only one or two fronds shot up again, these being removed by hand-pulling.

The cost of treatment was $3.00 per acre.

Estate	Type of cover treated	Type of spray used	Rate of spraying gallons per acre	Strength of spray	Costs per acre	Weather conditions	Result of treatment
A	Thick Grass (*Axonopus compressus*)	(a) Sodium chlorate	100	2 per cent	$4.50	Showery	Scorched tops: no permanent damage
		(b) Anti-malarial oil	40	Undiluted	$9.00	Showery	All above-ground shoots killed: no permanent damage
B	Lalang Grass Carpet grass (*Axonopus compressus*) "Sani pillu" (*Paspalum conjugatum*)	Arsenic	80 to 100	5 per cent (normal)	$9.00	Fairly dry	Growth above ground killed; new shoots appearing after 3 weeks
C	"Sani pillu" (*Paspalum conjugatum*)	Arsenic	20	(i) 5 per cent (three successive applications)	$6.50	Dry	Tops only were killed; Regeneration in two months. Stagmoss killed, but wild "coffee" only scorched
			20	(ii) 10 per cent	$4.50		
			20	(iii) 15 per cent	$7.00		

Estate	Type of cover treated	Type of spray used	Rate of spraying gallons per acre	Strength of spray	Costs per acre	Weather conditions	Result of treatment
D	Lalang Grass	Sodium chlorate	(a) 25 (Hand-pulling was done after spraying)	2 per cent (three successive sprayings at 10 days interval)	High	Fairly dry	(a) lalang grass disappeared in 18 months
			(b) Large volumes	2 per cent (successive sprayings)	$300.00		(b) lalang grass killed and other plants established
E	Lalang Grass	Sodium chlorate	25	2½ to 10 per cent (two or three successive sprayings)	$1.40 to $4.30	Fairly dry	Tops only killed; regeneration occurred in a short time
F	Stagmoss (*Lycopodium cernuum*)	(a) Sodium chlorate	20 to 25	2½ per cent	About $1.00	Fairly dry	(a) Stagmoss killed, and better bush types of covers only scorched.
		(b) Copper sulphate	20 to 25	5 per cent	$5.00	Fairly dry	(b) Stagmoss killed; other plants scorched.

Estate	Type of cover treated	Type of spray used	Rate of spraying gallons per acre	Strength of spray	Costs per acre	Weather Conditions	Result of treatment
G	Bracken (*Gleichenia linearis*)	Arsenic	(a) 20 to 25	(a) (i) 5 per cent (ii) 3½ per cent (iii) 2½ per cent		(a) Rain within two hours	(a) No effect
	Carpet Grass (*Axonopus compressus*)		(b) ditto	(b) ditto		(b) Dry	(b) Stagmoss only killed at each strength. Grass scorched, regenerated in 3 weeks
H	Thick stagmoss	Arsenic	20	5 per cent followed by 3½ per cent	$5.00	Dry	Tops completely killed, but roots only partially dead
K	Stagmoss and Bracken	Arsenic	20 to 25	5 per cent	$2.50	Dry	Both plants killed; a little hand-pulling required for final eradication some two months later
L	Heavy Bracken	Arsenic	20 to 25	5 per cent	$3.00	Dry (mid-day)	Bracken completely killed; a little hand-pulling required later

Conclusions

Successful eradication of areas of bracken and stagmoss can be achieved by spraying methods if care is taken; the cost of killing these plants in this way compares very favourably with other methods like hand-pulling or "changkolling." Lalang and other grasses, and bush types of covers, when sprayed, are only checked in their growth and are not permanently injured, since their root systems are able to produce fresh shoots very quickly after treatment, and there is also a considerable amount of new growth arising from the germination of seeds.

Solutions of sodium chlorate and arsenic weed-killer are effective on stagmoss, whilst the killing of bracken is accomplished best by means of the arsenic compound. The optimum concentrations appear to be a 2.5 per cent solution of sodium chlorate, and a "1 in 20" dilution of the arsenic compound. The mechanism of the action of arsenic compounds on some plants is, very simply, as follows. The arsenic is dissolved in a strongly alkaline or acid medium and this medium kills the living cells of the leaves and stems, rendering them permeable to the arsenic solution. In this way the arsenic enters the plant and is carried down to the roots, until the whole plant is killed. Spraying must be done in dry weather, since rain, even on the same day as the spray is applied, is liable to neutralise the effect. In this connection the best time of spraying would seem to be the middle-day hours, between 10 a.m. and 2 p.m.

In view of modifying conditions, it is apparent that the use of sprays for control of weeds has a definitely limited application in Malaya. The rainfall is high and during the major part of the year daily rain is a common occurrence. Heavy morning dew is another restricting factor, and bearing these facts in mind, it would only appear satisfactory to use liquid sprays during the two dry spells which occur, from January to March and from August to September, though the application of this restriction will vary according to local conditions.

The cost of successful spraying lies between $2.00 and $3.00 per acre, as against a figure of $5.00 to $10.00 per acre for other methods of eradication of noxious growths. Neither the arsenic nor the sodium chlorate are applied in sufficient strength to harm the soil or the rubber trees (roots or tapping panels). The arsenic spray (diluted) may tend to irritate the skin of human beings, and in the undiluted form is a strong irritant and poisonous. All chlorates are highly inflammable and it may be counted as a disadvantage of using chlorates that, when the dead plant material dries the dried chlorate solution will increase the inflammability of material which already catches fire

very easily. During the actual spraying, practically none of the spray reaches the ground, most of it being caught by the aerial parts of the bracken and stagmoss and in this way young plants of better types of covers are uninjured and can grow through the killed material which was originally growing above them.

Killing the weeds by spraying obviates the disturbance of soil, such as occurs when a "changkol" is used, and this is of great advantage where the plants have to be killed in bunds or pits or on steep hillsides, in that the risk of soil erosion is minimised. Further, no damage to the rubber tree roots can take place.

It may be an advantage to use sprays on heavy lalang and other grass patches as a preliminary measure to make easier the subsequent digging required for their eradication.

Some attention should be devoted to the use of dilute sulphuric acid sprays and also to treatment with other types of weedicides, such as sodium sulphocyanide, though with the use of sulphuric acid there is the need for considerable care in the handling of the undiluted reagent.

Summary

1. Details of experiments with weed-killers on various types of natural covers are presented.

2. Sodium chlorate and arsenical weed-killers appear to be most effective on bracken and stagmoss.

3. Lalang and other grasses, and bush types of covers, are not seriously damaged by the weedicides under consideration.

Acknowledgement

Acknowledgement is made to the various estate managers who have reported their experiences in the use of the sprays.

December, 1934

Addendum

The above article was prepared by the writer before going on leave in December 1934, and during 1935 one or two developments have appeared which are recorded below.

1. Sodium arsenite is now obtainable in Malaya and can be used very effectively for controlling grasses and covers, with the advantage that it is also cheap. Solutions of strength from 0.25 to 1 per cent have been used effectively in controlling grasses and lalang (scorching and killing back the tops, without doing

any permanent damage to the roots) and the chemical costs about 20 cents per lb.

2. Sulphuric acid has been tried, but is not likely to be used to any extent because of its cost and the danger in handling it (risk of burns).

3. Calcium cyanamide has proved effective in controlling areas of stagmoss and further experiments are in progress. This chemical has a fertilising value in addition to its value as a weedicide, and thus, although very expensive merely as a weed-killer, the extra gain to the rubber trees (nitrogen, and possible calcium) must be considered in its use.

4. Control of thick covers of leguminous creepers, in order to reduce competition with the rubber trees, may be achieved by spraying methods, and experiments are in hand dealing with this point. A light spraying with chlorate or arsenite will kill the plant leaves, and perhaps some roots, but will leave sufficient plants alive which can regenerate.

December 1935

REPLANTING*

BY

A. Moore

Before describing the operation of replanting on rubber estates, it would be best to consider the principal reasons for doing it.

Deteriorating Old Rubber

The first and most obvious reason is that much of the rubber in this country is getting old. Perhaps this is a premature old age due to bad tapping, the ravages of disease, neglect of soil conservation, and other such causes, but whatever it might be due to the fact remains that a very large part of our rubber yields under 400 lbs. per acre per annum and of this an alarming proportion is giving less than 250 lbs. Exact figures are difficult to obtain as, under restriction, estates are not in full tapping. The figures supplied for assessment purposes are derived from yields obtained during the slump years of heavy tapping following the resting of the previous restriction period and, of course, the rubber was younger then. They do not truly reflect the present situation and it is now generally agreed that such yields will never again be obtained from the old rubber trees we have now. Even with manuring and the cultivation of natural covers, yields are not likely to exceed those of the years 1929 to 1933, and in many cases the most that can be hoped for is the prevention of further deterioration. Besides, the older the rubber the slower its response to manuring. Improvement in foliage might take place rapidly but bark renewal, on which yields so largely depend, is a much slower process. It might be many years before yields have increased enough to pay for the manuring and by that time, on account of increasing age and losses due to disease, most old rubber areas would be uneconomic anyhow. With this unfavourable prospect in view for so much of our old rubber, replanting as a regular policy will soon commend itself more and more to planting companies and eventually, perhaps, to small-holders also.

Improved Planting Material

The second great reason for replanting, more important even than the first, is the great improvement in planting material which

*Lecture given at the Annual Conference of the Incorporated Society of Planters at Malacca on 20th September, 1935

has taken place in recent years. Budgrafting and seed selection have made such strides that no one who can afford it should refuse to consider the replacement of old low-yielding trees with modern high-yielding ones. As yet there are no large areas of budgrafted rubber which have been in bearing long, but the early results obtained so far indicate quite clearly that yields will be much greater than those obtained from mixed seedling rubber. Estimates of yield from budgrafted areas still vary considerably but 1,000 lbs. per acre per annum, which was once thought high, is now looked on as a very moderate expectation; 1,500 lbs. per acre is regarded as quite a reasonable possibility, and some enthusiasts optimistically hope for annual yields of as much as a *ton* of dry rubber per acre. There are many estates where, owing to loss of trees by disease and deterioration of those that remain, replanting even with mixed unbudded seedlings would be profitable. Now, with such high-yielding planting material available, even estates possessing comparatively good old rubber are beginning to realise that it is worth while to cut it out and replant.

Greater Profits

The third important reason for replanting is bound up with the second one and with the future price of rubber. When costs are discussed later in this lecture it will be shown that, if the price of rubber remains at about 20 cents per pound, replanting will pay for itself entirely in roughly a dozen years and leave the owner with a high-yielding property instead of a poor one. The question is, "What will happen if the price of rubber does not remain around 20 cents?" In that case, instead of regarding the cost of replanting as a charge on revenue it must be looked on as an addition to the capital value of the estate whose dividend-earning capacity has been greatly increased thereby. The argument is difficult to state in a few words but what it amounts to is that, if the price remains good, old rubber areas might do quite well but replanted ones will do even better and the outlay on replanting will soon be recovered. On the other hand, if we have another slump, the companies with high-yielding replanted areas, although perhaps more highly capitalised on this account, will have the best chance of surviving and of even paying dividends. Whichever way one looks at it, *and whatever the price of rubber*, high-yielding estates are bound to do better than low-yielding ones. In good times they make most profit and in bad times they make least loss. There may be occasional exceptions to this rule, as for example when, during a slump, circumstances are such that it is better for an old estate without reserves to go into liquid-

ation rather than try to raise funds for replanting, but in general it holds good so long as rubber is saleable.

Chance to improve Soil

The fourth great reason in favour of replanting is the opportunity which this provides of reconditioning the soil. Until the last ten years or so care of the soil was almost entirely neglected on rubber estates. On the flat coastal lands this has not been very serious but on undulating and hilly estates the loss of soil due to erosion has been nothing short of tragic. In addition to the wholesale transportation of soil by erosion, conditions under clean-weeding are such that humus formation is greatly retarded and cannot keep up with the consumption. The part which humus plays is not fully understood, but it is known to be a most important constituent of the soil. Without it beneficial bacterial activity almost ceases, and, moreover, recent research work in Europe seems to indicate that artificial manures do not have their full effect unless a good supply of humus is present. Replanting provides an opportunity of repairing some of the loss of humus and of improving the soil generally, by growing leguminous cover plants and later natural jungle covers in conjunction with such soil conservation methods as terracing and bunding.

Labour

These four reasons for replanting are the principal ones and apply to almost all estates possessing old rubber. There are other reasons, of less general application, of which the question of labour might be mentioned in passing. We all know how when the slump came and nearly all field works on estates were suspended, thousands of labourers, often of long service, were sent back to India or China. The result was that, when the price of rubber rose and money became available for much needed maintenance work, there was a serious shortage of labour. Labourers could not be brought back fast enough and there was an undignified scramble for those who had remained in the country. If those companies which could have afforded it had commenced replanting at the beginning of the slump, not only would they have done it much more cheaply but they would also have been able to keep their labour on the spot and avoided much of the trouble which came later. The slump has lifted, we hope for ever, and it is no use deploring having left undone the things which we ought to have done, but we must not overlook the fact that a similar situation with regard to labour still exists. Owing to restriction and the still rather low price of rubber, estate

labour forces generally are well below their full strength. If the price of rubber rose so as to permit some of the still neglected maintenance work to be done, or if the export allowance were to be increased unexpectedly, there would again be a shortage of labour. To be doing some replanting, even on a small scale, means having a reserve of labour on the estate which will be most useful in such emergencies.

Now we can go on to the description of the operation of replanting. It is not proposed to describe in detail the various field works, as you are all familiar with them, but emphasis will be given to the points requiring special attention.

Selection of Area to replant

To begin with, there is the selection of the area to replant. The natural impulse is to replant the worst part of the estate first, so as to make the loss of revenue due to cutting out as small as possible, but this is not always the wisest thing to do. On some estates, of which there are many unfortunate examples here in Malacca, the worst parts are so bad that only very lavish expenditure on manures would make replanting possible. Even then the results might be disappointing and would discourage further replanting. Every case must, of course, be judged on its own merits but in general the most suitable areas to select for replanting are those where the soil is still good but where the yield has been reduced through old age or loss of trees by disease. In this way there is no great loss of revenue through cutting out and yet, the soil being still fairly good, the replanted rubber can be expected to do well. Very poor land should be replanted last, and, pending replanting, efforts should be made to improve the soil by the growth of suitable natural covers.

It might be emphasized here that a progressive replanting programme should be planned as long beforehand as possible. The reason is that one usually has to decide whether to manure the existing old trees or to cut them out and replant. For financial reasons, or because the old trees still have a few more years of useful life, it might be decided to defer replanting. If this is the case an estimate should be made of the date when replanting will be carried out to enable one to decide whether it is worth while to manure now. With old rubber, it takes a long time for manuring to cause an increased yield and thus by spending money on manuring one is practically committed to keeping the old trees for many more years. So, if replanting is not possible at once but is intended within say 5 years, it is a waste of money to manure the old trees since they will be cut out before they have paid back the cost.

Tapping to Death

Having selected the area for replanting, the next step is to tap it so as to get the largest possible yield in a short time and thus help to counter-balance the loss of crop during the period before the replanted rubber comes into bearing. The system to be used in this "tapping to death" depends on the length of time available, and should be such that the trees become exhausted just about the date it is intended to cut them out. If the decision to replant is made suddenly, so that there are only 2 or 3 months left before felling, a very drastic system such as the daily tapping of two cuts can be employed. The cuts would each be half the circumference of the tree, as wide apart as possible on opposite sides, and tapped down to the wood with virtually unlimited bark consumption. If replanting has been foreseen a year or so ahead, a more moderate tapping system planned to last that time, such as two half-cuts tapped alternate-daily, will be more profitable.

Recently a method of tapping to death during the actual process of replanting has been suggested. The proposal is to cut off the branches of the old trees and tap the stumps whilst the work of replanting and establishing cover plants is going on. Even if the yield from the pollarded stumps is poor it will not matter a great deal in these days of restriction, as the exportable allowance can, or should be, easily obtained from the other parts of the estate. When the stumps are no longer worth tapping they will be sawn off at ground level and laid along the contours to help in preventing soil erosion. This method has not yet been tried but we hope to be able to experiment with it on a large scale soon. It is, of course, only applicable to areas where there is no root disease, that is to say where it is not necessary to do any digging and root extraction after felling the old trees. Most rubber estates originally planted on virgin jungle land contain a great deal of root disease, necessitating much digging over before replanting can be done with safety. On the other hand estates where the land was used for growing other crops such as pineapples, sugar, dry padi, and so on, before planting with rubber, are often almost free from root disease, and if this suggested method of pollarding the old trees and tapping the stumps, whilst replanting is going on, proves successful, it might be practised with much saving of time and money. However, although promising, it has yet to be proved. Too much faith must not be placed in it at this stage but any estate with suitable land should find it worth a trial.

Elimination of Root Disease

In the ordinary way, after tapping to death, the old trees are felled and the roots examined for disease. Where disease is

found the soil should be dug over to a depth of 18 inches and all diseased roots extracted and burned. The roots of healthy trees can be left to rot in the ground and on heavy land will help to improve water percolation and drainage. The lighter branches of the felled trees can be burned together with the diseased roots, but this should be done carefully to avoid extensive scorching of the soil and destruction of humus. The heavy branches and trunks should be placed along the contours to act as stopwashes unless, of course, they can be used or sold as firewood.

No accurate estimate of the cost of the digging to eliminate root disease can be made, since it varies so widely. On light sandy soil with little disease it is negligible. On heavy clay land with much disease it might reach $30/- per acre, or even more, but the work is much too important to be neglected. One of the few advantages which replanting has over planting from virgin jungle is that it provides an opportunity of starting with disease-free ground, and this opportunity should be fully exploited, as failure to do so can result in serious and unnecessary loss. There have already been cases of replanted areas where the old trees were merely sawn off at ground level and within two years some 45% of the young rubber trees, and most of the bush covers, were infected with root disease. The cost of checking the disease now will be greater than that of proper digging before replanting, and the areas are permanently damaged.

Planting

After the disease work has been done, terracing or lining, holing and planting are carried out in the usual way, and need not be described to you. Normally, about 200 holes per acre are to be recommended. As regards planting material, where replanting has been foreseen long enough beforehand, nurseries should be established early for the multiplication of budwood and to provide sufficient budded stumps and/or stumped buddings for planting up the whole area. This saves much time compared with budding in the field.

Where replanting is undertaken at short notice, and it is necessary to bud in the field, we recommend that one good basket plant and 4 germinated seeds should be planted per hole, to be sure of having enough good plants for budgrafting later. The number of plants per hole can be reduced to two within 6 months, to avoid wasting manure on the unwanted ones. When the plants are ready for budding the latest advice regarding choice of clones etc. can be obtained from the Botanical Division of the Institute or, if it is decided to plant clonal seed instead of budgrafting, all available information on this point will also be given.

Cover Plants

As soon as possible, after digging over for disease and making terraces, cover plants should be established. Where natural jungle plants were cultivated previously under the old rubber all except the best types should be removed. The debris may be buried, piled into heaps or contour bunds, or, where it is very dense, burnt in small heaps with as little destruction of humus as possible. Many undesirable types of natural cover, particularly grasses, bracken and rhododendron, which are partially checked by shade, spread rapidly once the shade is removed and if not eradicated at the start become expensive to control. This applies especially to a plant called *Eupatorium odoratum*, sometimes known as "Siam weed" or "German weed". This plant appears to have come from Siam and is working its way southwards. It does not seem to have reached Malacca yet, but in Kedah and Northern Perak it is becoming a serious pest in young rubber areas. Desirable jungle plants such as wild coffee, wild ginger, cassia, etc. should be retained as they will not only supplement the "artificial" leguminous covers specially planted but will form the nucleus of a natural cover in later years when the "artificial" cover plants have died out. As regards which "artificial" leguminous covers to plant, the choice depends largely on the lie of the land. The chief purpose of covers is to protect the soil from sterilisation by the sun and from erosion by rain. Both bush covers and creepers provide shade from the sun, but creepers are far more effective than bushes in preventing soil erosion. Unfortunately, as work in the last few years has shown, creepers have the disadvantage that they seriously retard the growth of the young rubber, whereas bush covers do not. Moreover, on heavy land, the deeper root systems of bush covers are of great value in opening up the soil and improving water percolation. Hence, on flat land, or on gently undulating land where erosion is not difficult to prevent, bush covers are best. On hilly land, where bushes would be unable to prevent erosion, creepers must be used. On medium slopes a combination of creepers on the terrace edges, to prevent their being broken, and bushes in between, is suitable. Whatever covers are used it is generally desirable, and in fact necessary, to manure them in the early stages in order to establish a strong growth quickly.

Menace of Soil Erosion

The importance of rapidly establishing cover plants to prevent soil erosion can scarcely be over-emphasized. In the past, not only in Malaya but in all new countries and in many old ones, the

seriousness of the erosion problem has not been realised and few steps have been taken to fight it. Recently world interest in the prevention of erosion has been aroused, and, although it is rather a digression from the main subject of this lecture, some of the results of research into this problem are of such vital importance that they are well worth bringing to your notice. Quite naturally, it was in countries where large quantities of food crops are grown that the menace of soil erosion first caused alarm. Whether we like to think it or not, we all live on the products of the top few inches of soil and to realise that this is slipping into the rivers and oceans at the rate of literally *hundreds of millions of tons per annum* is most disquieting. This menace is worldwide. It affects us in Malaya not merely as rubber growers but also as earthbound humans who cannot live without eating.

The Director of the United States Soil Erosion Service is the authority for the following figures, collected on a research station in Missouri. Equally convincing ones can also be obtained from other countries, more particularly some of the African Colonies. On loamy land with an 8 per cent slope, when completely free of vegetation, an average of *112 tons of soil per acre per annum* was lost by erosion. Under maize, *60 tons* were lost: under grass, only *one third of a ton* was lost; and under alfalfa, a very close-growing plant, only *one-fifth of a ton of soil per acre per annum* was washed away. These figures mean that on clean-weeded land the topsoil, which took centuries to accumulate would be completely stripped off in less than a *dozen years*, but under alfalfa it would last *five thousand* years.

Now we here are not much interested in keeping our estates going for the next five thousand years, but we do want to keep them for more than a dozen. The only way to do so is to guard carefully what little soil remains. During replanting it is easy to provide high-yielding planting material and plenty of manure, but these alone cannot ensure success. If they could we should be able to grow rubber on the seashore. As it is, we need soil, and as soil cannot be made to order we must do all we can to maintain and improve that which we have. In the earlier days of rubber planting under clean-weeded conditions, enormous quantities of soil were lost. The land will not stand it a second time. Replanting offers handsome profits, but they will only be realised if the lessons in soil management, taught us at such great expense, are applied intelligently.

It might seem that the figures just given exaggerate the dangers of soil erosion as regards rubber estates in Malaya. This is hardly so. Rainfall is not stated but we may be sure that the rainfall in the corn lands of Missouri is neither so great nor so

intense as in Malaya. Moreover, those results were obtained from land with only an 8 per cent slope, *i.e.*, 1 in 12½, which, as anyone who has traced an estate road knows, is quite a gentle slope. Much, if not the greater part, of the rubber in this country grows on steeper slopes than that, which makes the matter still worse. It is therefore of prime importance in replanting that, in addition to terracing and bunding on hilly land, cover crops to protect the soil should be planted immediately and given unremitting attention.

Manuring

Next comes the question of manuring the replanted rubber. On flat coastal clay land, where there has been very little loss by erosion and where the soil is naturally rich, manuring might not always be necessary. In all other cases, regular manuring can be regarded as absolutely essential. The quantities of manure and the frequency of application will depend on the quality of the soil, which is best judged by the progress of the young trees, but it is advisable to allow for carrying out the full course. The first application of manure should be made in the planting hole at the time of planting. A "complete" fertiliser should be used, *i.e.*, one containing all three of the principal plant foods, nitrogen, phosphate and potash, and should preferably be of an organic type. Normally, further manuring in increasing doses is required every six months during the first two or three years, except during the budgrafting period, and then annually until maturity. Manuring after that will probably be required but is too far ahead to be forecast now. It is possible that careful management of the soil during the years before the trees come to maturity will greatly reduce the need for subsequent manuring. During the immature period, which is our chief concern, manuring should be with complete fertilisers. After the first application of a complete organic fertiliser it is usually safe, and much cheaper, to change to soluble inorganic ones or to a mixture of both kinds. As the trees approach maturity, if the growth is good, sulphate of ammonia, which supplies nitrogen only, can be used instead of complete fertilisers and will reduce the cost considerably.

Cost of Replanting

The total expense of replanting will vary very much on different estates with different types of land, different labour conditions, and so on, also we are still lacking in experience, so no accurate details can be given. It is, however, safe to say that the cost of felling, digging, terracing, cover crops, planting and maintenance to maturity, will be between $100 and

$160 per acre, exclusive of overhead charges and manures. The cost of manures will vary according to the stand of trees and the quality of the soil, but from $40 to $70 per acre will have to be spent during the immature period. Overhead charges, that is quit rent, salaries, etc., do not come into the argument either for or against replanting, as they have to be paid whether the area is replanted or not. The total cost of replanting up to maturity is therefore between $140 and $230 per acre, according to local conditions. Average costs will be about $55 for manures and about $130 for all other field works, or a grand average of about $185 per acre until the area comes into bearing.

Replanting *versus* Manuring

It now remains to discuss the economics of replanting in terms of comparative figures instead of broad generalisations. Any area of old rubber can be dealt with in three ways. It can be:—

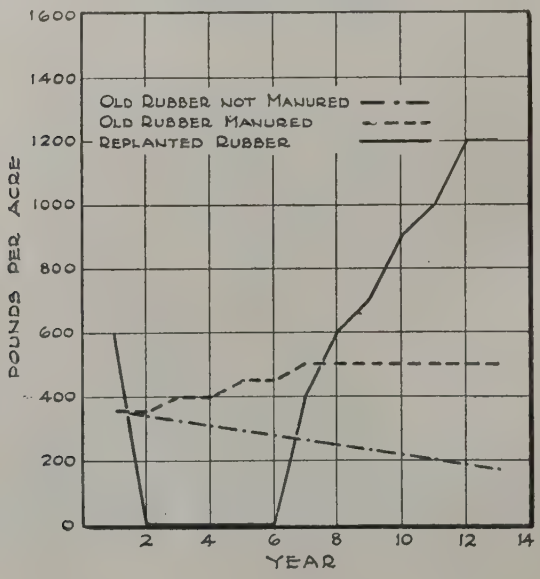
(a) Not manured
(b) Manured
(c) Cut out and replanted.

Let us assume that the old rubber is about 30 years old and is now yielding 350 lbs. per acre per annum. The trees are old but not decrepit, and would respond to manuring. If it is not manured its yield will decrease steadily, and this decrease can be reasonably estimated at 15 lbs. per acre per annum. If it is manured regularly its yield will increase slowly and may be estimated to reach a maximum of 500 lbs. per acre per annum after about 7 years. If the area is replanted with up-to-date high-yielding material, the tapping-to-death of the old trees will yield say 600 lbs. per acre, then for 5 or 6 years there will be nothing, until, in about the 7th year, tapping of the young rubber will commence with rapidly increasing yields. For the purpose of this lecture, in order not to run the risk of exaggerating the advantages of replanting, it will be assumed that the yield from the replanted rubber will reach a maximum of 1200 lbs. per acre per annum in about the 12th year. This estimate is probably too modest. Even so it is sufficient to prove the value of replanting, as is shown by the following table in which are given the yields which may be expected during the next dozen years from an old area (a) if not manured, (b) if manured, (c) if replanted; together with the cost of manuring in cases (b) and (c). The progress of the yields in the three cases is also shown graphically below.

TABLE

Year	Old Rubber Not Manured		Old Rubber Manured		Replanted	
	Yield lbs. per Acre	Cost of Manuring	Yield lbs. per Acre	Cost of Manuring	Yield lbs. per Acre.	Cost of Manuring
1	350	Nil	350	$15	600	
2	335	,,	350		(tapping	
3	320	,,	400	$15	to death)	
4	305	,,	400			
5	290	,,	450	$15		$60
6	275	,,	450			
7	260	,,	500	$15	400	
8	245	,,	500		600	
9	230	,,	500	$15	700	$15
10	215	,,	500		900	
11	200	,,	500	$15	1000	$15
12	185	,,	500		1200	
Total	3210 lbs.	Nil	5400 lbs.	$90	5400 lbs.	$90

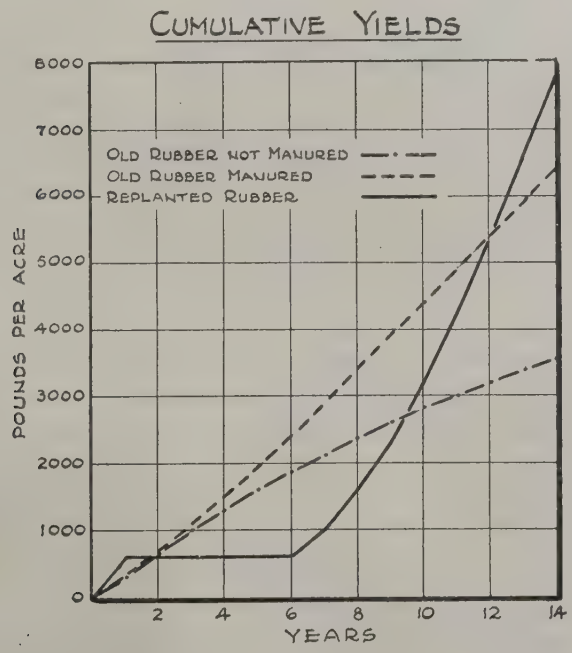
ANNUAL YIELDS



The two main facts which the above table and graphs illustrate are:—

(1) That during a dozen years a suitable area of old rubber manured at a total cost of $90 per acre can be expected to give 2190 lbs. of rubber per acre more than if it had not been manured. That extra rubber, after adding the extra tapping, manufacturing and packing charges on to the charge for manuring, will have cost well under 10 cents per pound to produce, so, at the present selling price of rubber (about 20 cents per lb.), manuring is evidently very profitable. *But,*

(2) That if the area is replanted, at the end of a dozen years it will have produced as much rubber as if the old trees had been kept and manured, *i.e.*, 5400 lbs. per acre, and the same amount of money will have been spent on manuring in each case, *i.e.*, $90 per acre. Unless it so happened that the price of rubber was high during the first half dozen years and low during the second, the balance would at least be even at this point, *but,* whereas the



old rubber would then be over 40 years old and getting near to the end of its life the replanted rubber would only just be reaching its best. It would be yielding at least 700 lbs. per acre per annum more than the old rubber would, even assuming the

old rubber could continue to give 500 lbs. per acre, which is extremely unlikely. In the 13th year alone this excess of yield would, at present prices, pay for the cost of replanting (about $130 per acre, above), the manures having already been paid for, and we should start the 14th year with an area on which all extra charges had been recovered and which would be yielding at least 1200 lbs. per acre per annum.

Conclusion

Figures like these speak for themselves. They are based on conservative estimates and yet they show clearly that replanting is profitable enough to deserve immediately the very serious consideration of all rubber growers. It is even more attractive now than formerly, since it has been announced (in August 1935) that under restriction the deduction from standard production in respect of areas cut out for replanting will be only 110 lbs. per acre. If restriction is allowed to finish at the end of 5 years, planting on virgin jungle land will be permitted in 1939. That would naturally be preferable to replanting old rubber land but it is by no means certain to happen. In any case it is to the advantage of all concerned—whether producers or consumers or governments levying taxes—for as much as is economically practicable of the old rubber now in existence to be replaced with new high yielding stock. All rubber growers therefore, from the largest European company to the smallest of Asiatic small-holders, possessing suitable land and able to raise the necessary money, would be well advised to take advantage of the present restriction period to replant as much as the regulations permit.

APPENDIX

Costs of Replanting

The following is an estimate of the costs of an average replanting programme, the details of which will vary considerably on different estates and on different types of land.

Item	Cost per acre	
Felling	$45	(variable)
Digging	10	(very variable)
Terracing and Holing	15	
Cover Plants, including manure ...	10	(variable)
Nurseries and Planting	7	
Budgrafting	12	
General upkeep to maturity ...	20	(variable)
Manuring	55	(see below)
Sundries, say	11	
Total ...	$185	

Details of the manuring of the replanted rubber up to maturity are shewn below. These figures are based on an initial stand of 200 trees per acre, gradually thinned out to about 130 before maturity. The amounts of manure and frequency of application will vary according to the type of land and progress of the plants, and under good conditions some of the later applications may be lessened or even omitted.

Time	Manure per hole	Cost per acre (without labour)
At planting	½ lb. Sterameal ...	$ 7.00
6 months later	3 ozs. Enpekay No. 1	2.00
(No manuring during budgrafting period)		
9 months after budding	¼ lb. Enpekay No. 1 ...	2.50
15 „ „ „	½ „ „ „ ...	5.00
2 years „ „	¾ „ „ „ ...	7.50
3 „ „ „	1¼ „ „ „ say	10.00
4 „ „ „	2 „ „ „ „	13.00
5 „ „ „	2 „ sulph. ammonia „	8.00
	Total ...	$55.00

NOTE ON TOUGHNESS OF SOLE CREPE

From time to time producers of sole crepe have referred to the Institute complaints which have been made by buyers in temperate climates, against the softness of the product. Samples of the supposedly defective rubber have been returned by the buyer and on examination in Malaya have been found to be to all intents and purposes normal sole crepe. The complaint usually made is that the rubber is soft and lacks toughness, or that it possesses no resilience. In some cases where the producer has received an order on the basis of a sample accepted by the buyer, the producer has retained duplicates of the original sample and it has been possible to test these against material returned subsequently by the buyer from rejected consignments.

In testing for resilience the instrument employed at the Institute is a modified form of scleroscope. In the operation of this instrument a small steel weight with a rounded end is released from a fixed height above the sample, falls under its own weight and rebounds vertically. The height of the rebound is measured on a scale and gives an indication of the resilience of the sample. In a typical recent instance in which the buyer had rejected a consignment on the grounds of softness and lack of resilience compared with the original sample, the rejected material and the producer's duplicate of the original sample were each tested in twenty spots by the scleroscope and recorded identical average readings of 68 on the instrument scale. This indicated that, under Malayan conditions, material from the large shipment did not in fact lack resilience when tested against the sample. Observations on these samples are typical of many which have been made from time to time and the reason for the buyers' complaints is not at first obvious.

Some time ago the opportunity arose for personal enquiry and discussion of this matter with brokers who handle large quantities of sole crepe in London, and in the course of these discussions it became plain that the probability of complaints being made against the hardness or resilience of sole crepe was largely bound up with temperature conditions and time of storage in European warehouses before sale to the user. When the demand for sole crepe is brisk and it is being delivered to the user almost straight from the ship, it is common at times for complaints against softness to be numerous; when trade is less good and supplies of sole crepe may be in the warehouses for two or three months before sale, complaints are very infrequent. These experiences provide the clue to the real nature of the users' complaints.

When raw rubber is stored at a low temperature for several weeks, a partial and temporary crystallization is induced in it. It becomes stiff and opaque and not unlike leather in its resistance to bending. The user, who is usually a shoe-maker and who has no means of testing the properties of the commodity, save by feel and appearance, is naturally disposed to favour a rubber which at the time of purchase is opaque and which is tough and resistant to bending. Very few of the buyers appear to realise or to have observed that such a tough rubber rapidly loses its opacity and stiffness in a warm atmosphere and assumes the translucent flexible condition with which all Malayan producers are familiar. Because of the lack of appreciation by buyers that the opacity and apparent toughness or hardness of sole crepe is a purely transitory condition dependent upon temperature, complaints are often made against rubbers which are perfectly satisfactory but which because of not having been stored for some time in a cold place are translucent and flexible at the time of examinaton. This temperature effect is well-illustrated by further observation made on the two samples of sole crepe under reference. When the two samples had been stored in a refrigerator for two days at 40°F., they both hardened and recorded identical scleroscope readings of 55 as against the earlier value of 68 at Malayan room temperature (85°F). After ten days' storage in the cold, the samples were opaque, could only be bent with difficulty and showed identical scleroscope readings of 41 on the instrument scale. In this instance both pieces of rubber were clearly of good quality and the sole reason for complaint against the rubber from the large consignment was that, whereas the sample had reached the buyer in a tough, opaque, incipiently crystalline condition, the bulk consignment arrived unfortunately in the flexible condition in which it left the hands of the producer.

Producers who receive complaints against softness should not therefore be unduly alarmed and buyers are not justified in complaining on this ground unless they are absolutely satisfied that the grounds for complaint are more substantial than that of the simple temperature effect now described.

E.R.

Kuala Lumpur,

4th November, 1935

CREAMING LATEX WITH GUM TRAGACANTH

BY

EDGAR RHODES AND K. C. SEKAR

Recent work by the authors, on the gum tragacanth process for latex creaming, has been made the subject of British Patent No. 415,133 of which the text follows:—

Patent Specification No. 415,133

Application Date: Feb. 23, 1933. No. 5532/33
Complete Left: Jan. 9, 1934
Complete Accepted: Aug. 23, 1934

COMPLETE SPECIFICATION

Improvements relating to the Treatment of Rubber Latex

This invention relates to the treatment of rubber latex and particularly to an improved method of concentration or creaming.

It is known that a number of organic colloids when added to latex will cause the rubber globules to rise into the upper layers of the body of the latex, giving thereby an upper layer rich in rubber and a lower layer comprising the aqueous portion of the latex, the two layers being readily separable the one from the other.

It is further known that the speed with which the separation into the two layers takes place can be accelerated if the latex is treated with the organic colloid in the presence of an acid or of an alkali in such small quantity as not to cause coagulation. Certain weak organic acids, chiefly the fruit acids such as citric acid, tartaric acid, malic acid, and lactic acid, have been specifically mentioned as being suitable for this purpose.

In accordance with the present invention a method of concentrating rubber latex without coagulation thereof comprises treating the latex with an organic colloid in the presence of a substance (for example ethyl alcohol) which is neither alkaline nor acid and which is more volatile than water. In particular it has been found that the rate of creaming of latex with gum tragacanth can be greatly accelerated by treating the gum tragacanth with a small amount of certain non-acid, non-alkali, organic liquids before admixture with the latex. Acetone is a suitable substance for this purpose or an aliphatic alcohol such as methyl or ethyl alcohol. The amount of such organic liquid need not exceed five cubic centimetres per 100 cubic centimetres of original latex.

As an example of the increased rate of concentration with gum tragacanth containing such an organic liquid, the following may be mentioned. A colloidal solution is made up of one part by weight of gum tragacanth to 100 parts of water. Ethyl alcohol to the amount of two cubic centimetres per 100 cubic centimetres of latex to be treated, is mixed with the solution of gum. Of this mixture sufficient is added to the latex — which has previously been preserved with ammonia — to give 0.2 part by weight of gum tragacanth per 100 parts of the water phase of the latex.

The concentrating action will start in approximately one hour as compared with four or more hours for latex treated with gum tragacanth alone. The degree of concentration after 72 hours standing is higher than with gum tragacanth alone. In order to accelerate the rate of separation of the cream, treatment in a suitable centrifuge may be resorted to. The resultant concentrate may be completely dispersed in water to give a rubber latex which is not appreciably different from ordinary preserved latex, thus showing that coagulation has not occurred.

Concentrated rubber latex prepared in this manner possesses an advantage over similar forms in which fruit acids are employed to accelerate the action of the colloid, in that the ethyl alcohol is volatile and disappears when the latex is dried. In certain manufactures for which concentrated latex is employed a minimum of non-volatile matter other than rubber is considered desirable. Traces of non-volatile fruit acids remaining in the concentrate would not be so removed on drying.

Having now particularly described and ascertained the nature of the said invention and in what manner the same is to be performed, it is declared that the claim is:-

1. A method of concentrating rubber latex without coagulation thereof comprising treating the latex with an organic colloid in the presence of a substance (for example ethyl alcohol) which is neither alkaline nor acid and which is more volatile than water.

2. A method of creaming rubber latex by means of gum tragacanth, characterised by the fact that a small amount of a non-acid, non-alkali organic liquid more volatile than water is incorporated with the gum tragacanth for the purpose specified.

3. A method according to claim 1 or 2 in which the concentration or creaming of the latex is accelerated by carrying out the treatment in a centrifuge.

4. A method of concentrating rubber latex without coagulation thereof substantially as hereinbefore described with reference to the example given.

5. A concentrated non-coagulated rubber latex whenever prepared by treating latex by the method claimed in any of claims 1 to 4 and separating it from the residual liquid.

This patent will shortly be registered in the Straits Settlements, and the various States of Malaya. Producers are asked not to overlook the broad terms of British Patent No. 226,440 of Isidor Traube.

Kuala Lumpur,

19th December, 1934

CREAMING LATEX WITH TRAGON SEED GUM

BY

EDGAR RHODES AND K. C. SEKAR

As a result of investigations carried out at the Rubber Research Institute, a British patent has been granted for the use of carob seed gum or, as it is better known in Malaya, "Tragon A" as a creaming agent for latex.

The details of the patent are as follows:—

Patent Specification No. 430,935

Application Date: March 12, 1934
Complete Specification Left: Feb. 25, 1935
Complete Specification Accepted: June 27, 1935

COMPLETE SPECIFICATION

Improvements in and relating to the Concentration of Latex

This invention relates to the concentration of rubber latex and has especial reference to processes for the concentration of ammoniated normal latex by creaming, wherein creaming agents, usually colloid substances, are added to the latex and cause its separation into an upper layer of concentrated latex cream and a lower layer or layers containing mainly serum constituents.

It has been proposed to concentrate rubber latex by adding thereto mucilages such as Carragheen moss, Iceland moss, and diagum, i.e. a powder prepared from the seed pod of the locust or carob tree, in certain circumstances as an aqueous extract, and heating the latex for some time at 40—60°C.

It is usual to cream the latex for not more than 72 hours, and then to separate the cream for shipment; the disadvantage of processes for the concentration of latex in this manner hitherto effected has been the tendency of the latex cream further to separate into layers on standing, and one object of the present invention is to provide a process for the concentration of latex by creaming which will give a stable and homogeneous product of maximum concentration in a short period.

In accordance with the invention a process for the concentration by creaming of ammoniated normal latex involves the addition of a solution of carob seed gum as creaming agent, this gum consisting essentially of the hemi-cellulose material extracted from the seeds of the locust or carob bean *Ceratonia Siliqua*.

The invention also provides as a further aspect, by which a more highly concentrated and yet homogeneous and stable latex cream is obtained after a short period of treatment, an increase in the pH value of the latex prior to treatment by augmenting the ammonia content, preferably to about 1.5% by weight of the dry rubber content thereof instead of the more usual 0.5%, tests having shown that with normal latex ammoniated to this extent and treated with the carob seed gum as creaming agent according to the present invention, a concentrated latex of approximately 60% dry rubber is readily obtained which is homogeneous and stable in that it does not cream further on standing.

In the practice of the invention according to one example of the process, normal latex containing approximately 35% dry rubber by weight is treated with aqueous ammonia until its ammonia (NH_3) content amounts to between 1.5% and 1.6% by weight, whereafter there is added to the latex a freshly-prepared solution of carob seed gum consisting of three parts of gum per 100 parts by weight of water, the solution being prepared by boiling the gum with water.

A swollen gum can be prepared in the cold but the dissolved gum is preferred.

The proportions are advantageously 0.3 part of carob seed gum by weight per 100 parts of water in the latex, and during a period of 48 hours the latex separates into two portions, namely an upper layer of latex cream constituting about 55% of the original volume of latex and containing about 58.4% dry rubber content, and a lower layer constituted by a solution of serum substances in which, however, some rubber may be present.

The concentrated cream contains approximately 0.94% ammonia, and in spite of its high dry rubber content does not exhibit any tendency to re-cream on standing but remains homogeneous and stable and is consequently a very marketable product, easily handled by the consumer.

Apparatus in which the process can be conveniently carried out advantageously comprises a vessel with side taps so positioned that the cream can be run off without disturbing the serum underneath, thereby avoiding the disturbance and slight re-mixing of the serum and cream which is unavoidably attendant upon the use of a vessel having a single tap at the bottom. If desired also provision may be made for slightly heating the vessel so as to accelerate the creaming process and thereby reduce the time necessary to obtain a cream of the maximum concentration.

It is preferable in all cases to use a freshly-prepared gum solution in the treatment owing to the fact that the solutions are unstable and, when left, deteriorate as creaming agents.

By the process according to the present invention a creamed latex can be obtained after a short period, say 48 hours, having a high and definite dry rubber content and which is not liable to change appreciably by the time the latex reaches the consumer, the product being especially suitable for manufacturing processes where concentrated latex is usually employed.

Having now particularly described and ascertained the nature of the said invention, and in what manner the same is to be performed, it is declared that the claim is:—

1. A process for the concentration of rubber latex by creaming, involving the addition as a creaming agent of carob seed gum consisting essentially of the hemi-cellulose material extracted from the seeds of the locust or carob bean *Ceratonia Siliqua*.

2. A process for the concentration of rubber latex according to claim 1, wherein the pH value of the latex is increased prior to the treatment to accelerate creaming and to stabilise the resultant cream.

3. A process for the concentration of field latex according to either of the preceding claims, wherein the ammonia content is augmented to about 1.5% by weight on the dry rubber content, prior to treatment to expedite the concentration.

4. A process according to any of the preceding claims, wherein the creaming agent consists of a freshly-prepared solution of carob seed gum containing about three parts of gum per 100 parts by weight of water.

5. The product obtained by the process according to any of the preceding claims comprising a concentrated latex cream containing about 60% dry rubber.

6. The process for the concentration of rubber latex by creaming substantially as described.

This patent will shortly be registered in the Straits Settlements and the Malay States.

Producers are asked not to overlook the broad terms of British Patent No. 226,440 of Isidor Traube.

Kuala Lumpur,

29th October, 1935

THE SPECIFIC GRAVITY OF RUBBER IN LATEX

BY

Dr. O. de Vries (Groningen, Holland)

(*Reprinted from The India Rubber Journal Vol. 89 p. 343*)

In a study on the specific gravity of preserved latex, E. Rhodes[1] comes to the conclusion that the specific gravity of rubber in latex may be estimated at 0.902, and that the figure of 0.914, found by us several years ago[2], and the figure of 0.912 used as a basis for the tables in the contracts of the Rubber Trade Association of London, are high. Rhodes' figure is based on a large experimental material (852 samples of preserved latex from nine different estates), and agrees well with the estimated figure of 0.901, to which Scholtz and Klotz[3] came from 85 observations on fresh latex in Malaya.

Our figure was based on a large number of observations on normal estate latex, as well as on latex from specially tapped groups of trees; the difference between 0.902 and 0.914 is too large to be ascribed to experimental errors, although these of necessity are rather high, as the specific gravity of rubber can only be calculated by extrapolation over a zone much greater than the experimental zone itself. It seems of sufficient interest to subject these deviating results to a closer study, as this may, perhaps, throw some further light on a rather complicated problem which is not without practical interest.

Starting our investigations in the years 1916-1919, we had to reckon with different factors that might complicate the problem. It was not to be expected that the serum of different trees or plots of trees would show the same composition; physiological factors were sure to influence its content of proteins, mineral substances, and so on. Whether the specific gravity of rubber in latex was subject to variations, according to age of trees, size of rubber globules, content of proteins, etc., was far from clear at the outset. Moreover, complications were caused by the admixture of water, accidentally by rain, wet cups or buckets, or intentionally by the tappers, in that period when there were managers prepared to swear that their trees yielded a latex of 10-15% original rubber content, so common was dilution from one cause or another. We,

1 *Journ. Rubb. Res. Inst. Malaya* **5** (1934) 234
2 *Estate Rubber* (1920) p.38; *Archief* **3** (1919) 183 and 202
3 *Kautschuk* **7** (1931) 144.

therefore, began our observations without any preconceived supposition, collecting a large number of observations. It was easy to state that mixtures of latex and water follow the "mixing rule" (straight ratio between specific gravity and content). The study of the relations between specific gravity and rubber content in pure latex gave somewhat more trouble, because pure serum and pure rubber could not be investigated. In that time latex was still regarded as a liquid from which the rubber could not be separated by centrifuging; but even at present, now that centrifuging has become a common process, it is still impossible to separate the two phases in a pure form suitable for exact determinations of physical properties. Some agent has to be used, and this makes that we get neither the pure serum nor the pure rubber. It should not be forgotten that what we call "specific gravity of the rubber in latex" is in reality an imaginary figure, giving the specific gravity of a mixture not existent as such in the latex, but formed during coagulation and consisting of rubber globules, acid coagulable proteins, and substances absorbed by them according to the composition of the liquid phase (serum), the subsequent washing process, and so on. Scholtz, therefore, uses the, at first somewhat striking, term of "crepe content of latex", and one might, in accordance with this line of thought, perhaps better speak of the specific gravity of crepe rubber in latex, meaning that the figure is calculated for rubber of crepe composition.

In our investigations we mixed known volumes of latex (200 cc.) and of 2½% acetic acid (40 cc.), the specific gravities of which were first determined; the specific gravity of the clear serum was then determined, and this was recalculated to original serum[1]. From the specific gravity of the serum, determined in this way, and the specific gravity of the latex, the specific gravity of the rubber could be calculated. From numerous determinations on plots in different conditions (age, tapping system, and so on) it was found that the specific gravity of the serum and the rubber both vary slightly according to circumstances; a graph was drawn up representing the relationships for pure latex of different rubber content and the mixtures obtained by diluting with water.[2]

In presenting this picture schematically and in its simplest form in our book, *Estate Rubber* (page 40), we made the slip to write about "rubber content in percentage of weight" (i.e., grams of rubber per 100 grams of latex). This slip was soon discovered

1 See *Archief* 1 (1917), English text page 277 and figures in tables XIV—XXVIII; formula in *Arch.* 3 (1919), page 189 and 204 after the indicated corrections.

2 *Estate Rubber* (1920) page 112 and page 40.

during further investigations, and put right in a following publication (*Arch.* 10 (1926), page 19): the points for specific gravity of a mixture, the content of which is given in percentage of volume (i.e. cc. rubber on 100 cc. of latex), lie in a straight line (A in Fig. 1), as may be easily deduced from the formula: weight = volume × specific gravity. When the content is calculated as percentage of weight, the points for specific gravity do not form a straight line, but a slightly curved line (B in Fig. 1).

The same oversight has been made, both by Scholtz and Klotz, and by Rhodes; in their investigations the rubber content of the latex was determined as percentage of weight, and the line for specific gravity and content is erroneously extrapolated as a straight line. The formula connecting specific gravity (s) of latex (1), rubber (r), and serum (s), with percentage of weight (c) is as follows:—

$$S_l = \frac{(C_r + C_s)\, S_r\, S_s}{C_r\, S_s + C_s\, S_r}$$

In our own experimental material, when using percentages of weight, extrapolation (dotted line C in Fig. 1) would have given a figure for specific gravity of rubber of 0.908 instead of 0.914, therefore 0.006 lower. As it interested us to know the result in Rhodes' case, we calculated his figures by means of the above formula. Any two observations (Rhodes' Table I or V) may be used to calculate the specific gravity of rubber and that of serum; to make matters easier, we only made the calculations for two pairs, namely, his figure for average estate latex with 40% rubber (being probably one of the most normal and reliable), and for latices with 33⅓ and 50% rubber respectively. This gave us the following approximate figures:—

From 40% and 33⅓% :	$S_{rubber} = 0.9072$	$S_{serum} = 1.0195$
From 40% and 50 % :	$S_{rubber} = 0.9057$	$S_{serum} = 1.0207$
Average :	0.9065	1.020

Accurate figures might be obtained by using all of Rhodes' eleven points; but the above approximation is sufficient to conclude that Rhodes' figure for the specific gravity of rubber in latex should be corrected to about 0.9065 (or about 0.0045 units higher, in good agreement with our former result of 0.006).

This brings the two figures, 0.914 and 0.9065 closer together, but it still leaves a rather large margin. It seems probable that this, at least partly, may be explained in the following way.

The rubber tree yields a latex of different composition, according to the physiological conditions it has to meet, consisting

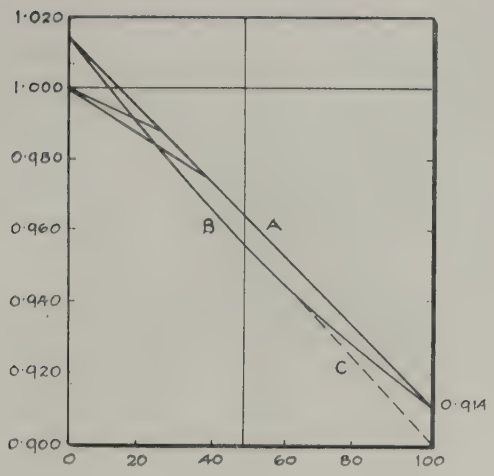


Fig. 1

Specific gravity of latex plotted against rubber content. Straight line A for rubber in percentage of volume; slightly curved line B for rubber in percentage of weight of latex; dotted line C probable extrapolation.

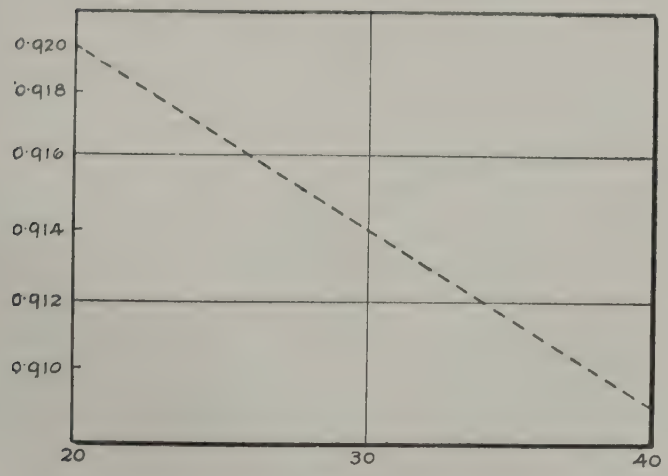


Fig. 2.

Specific gravity of rubber in latex of different original rubber content. Dots: figures from Table 1.

principally of its own condition (age, health, etc.) and the treatment it is subjected to. We found[1] the general rule to be: the more drastic the treatment, the lower the rubber content of the latex, the lower the total solids in serum (the specific gravity of serum), the higher the nitrogen and ash content of the crepe, the larger the rate of cure, and the lower the viscosity of the crepe. Longer tapping cuts, more tapping cuts, shorter tapping intervals, deeper tapping, pollarding the trees, tapping younger trees as compared with older ones, all have a tendency in the above direction.

In these and other investigations we used latex from plots of trees tapped according to different systems; from mild to drastic, as understood in those days, the figures[2] that interest us here are:—

TABLE I

	Rubber content of latex	Spec. grav. of rubber	Spec. grav. of serum
1 cut daily over ½ circumference ...	33.65	0.9135	1.0226
2 cuts „ „ ¼ „ ...	31.2	0.913	1.0223
2 „ „ „ ¼ „ ...	29.15	0.914	1.0219
2 „ „ „ ½ „ ...	26.6	0.916	1.0207
2 „ „ „ ¾ „ ...	22.6	0.918	1.0188
2 „ „ „ 1/1 „ ...	22.25	0.918	1.01895

Allowing for errors and uncertainties, there is a tendency for the calculated specific gravity of the rubber to decrease slightly, as the treatment is less severe and the rubber content of latex higher. This seems quite comprehensible, for in coagulation a certain amount of protein from the serum is precipitated with the rubber, and as the protein content of the serum does not change very much because of more drastic or more mild treatment, the amount precipitated with the rubber and included into the crepe must be proportionately higher when the ratio serum/rubber is higher. These proteins have a higher specific gravity than the rubber hydrocarbon (they sink in the serum, while the rubber globules float in it), so that the calculated specific gravity of "crepe latex" will be higher for heavily tapped trees. This is probably not the only cause, as may be easily seen when taking the difference in specific gravity between protein and hydrocarbon at about 0.2 and the increase in protein content at say 1%; but the amount of minerals and other substances also increases.

1 *Estate Rubber*, Chapter II and page 589.
2 See *Arch.* 3 (1919), page 199.

Since the time of our investigations tapping systems have changed considerably, and alternate day or periodical tapping have come into vogue; the rubber content of original latex, which in the years of daily tapping was 28-33%, and seldom reached 35%, is now given, both by Scholtz and by Rhodes, as 37-43% normally, rising in not infrequent cases (for instance, in 15% out of Rhodes' observations) to 46-50%. When we plot our figures (see Fig. 2) and, uncertain as they may be, extrapolate to higher rubber contents, a figure of 0.907-0.909 for 40% latex does not at all seem improbable. It would be very interesting if the specific gravity of rubber from trees under different physiological conditions, yielding latex of high as well as of low rubber content (for instance, daily yields from a plot in periodic tapping) could be determined, so that the above mentioned conclusions as to the physiological condition of the tree and its influence on the properties and composition of latex and rubber could be verified for present-day conditions.

Attention may be drawn to the figure of 1.020 which we estimated from Rhodes' observations for the specific gravity of serum. Addition of ammonia solution, and dilution of the latex with small amounts of water, which Rhodes mentions as probable, both would tend to lower the specific gravity of the serum, so that the original undiluted latex would have shown a figure higher than 1.020. In our investigations we found figures between 1.016-1.025, and estimated 1.020 as a normal value; trees under a mild tapping system and showing a high rubber content of the latex may be expected to give a serum with rather high specific gravity (see Table I above) so that a figure, higher than that calculated by Rhodes, seems to agree very well with what one would have expected.

There may be several other factors responsible for small changes in specific gravity of the rubber phase, causing small differences between Rhodes' figures and ours. For instance, the addition of ammonia may perhaps have an effect on the composition and the specific gravity of the rubber (what is its effect on the weight of crepe obtained from the latex?). It would have to be investigated what is the effect on the specific gravity of the rubber, of letting the precipitate of ammonium magnesium-phosphate and other substances (the sludge) settle out. And, further, the difference would have to be taken into account between fresh ammoniated latex in the East, as investigated by Rhodes, and latex in Europe, as it probably should form the basis for the tables of the Rubber Trade Association of London, and in which the crepe content, according to Bishop and Fullerton[1] is about 1% lower.

1 *Planting Manual* No. 4 (1932), page D 10.

It seems an interesting task for the competent investigators in the East and in Europe to follow up these issues, which may contribute much to elucidate different points, and bring us a better knowledge of the properties of latex rubber, which in recent years has made such a remarkable progress as a commercial form of rubber.

THE SPECIFIC GRAVITY OF PRESERVED LATEX

BY

EDGAR RHODES

(*Reprinted from The India-Rubber Journal, Vol. 89 p. 397*)

The Journal of the Rubber Research Institute of Malaya, 5, 1934, 234, contained a paper (1) on the specific gravity of preserved latex written by the writer of this note. The paper has recently been made the subject of constructive comment by De Vries (2).*

As a result of the examination of 852 samples of preserved latex, a specific gravity dry rubber content table was derived for preserved natural latices, and the dry rubber content range covered was wide enough to include natural unconcentrated latex in all the phases in which it is likely to be required by or become available to the commercial user. By the unavoidable expedient of extrapolation from the experimental results, a value of 0.902 was also derived for the specific gravity of the rubber phase in preserved latex. This value was in good agreement with the figure of 0.901 obtained by Scholz and Klotz (3) for "rubber" in fresh latex. On the other hand, De Vries (4 and 5), working with fresh latex had prevously derived a value of 0.914 for the specific gravity of the rubber phase, and the specific gravity table used by the Rubber Trade Association of London for preserved latex gives on straight line extrapolation a value of 0.912. It seemed that the value indicated by the work of De Vries and that deduced from the table of the Rubber Trade Association were probably rather high, and certain experiments with centrifugal concentrate and centrifugal concentrate-skim mixtures were cited which provided some confirmatory evidence of this conclusion.

In his recent communication to *The India-Rubber Journal*,† De Vries has pointed out that Rhodes, like Scholz, determined dry rubber contents as weight percentages, and extrapolated the relationship between these values and specific gravity as a straight line; he makes the point that this procedure is not strictly accurate, for whereas the relationship between the dry rubber content of a latex when expressed as a volume percentage, and its specific gravity can be represented by a straight line, the relationship

*Reproduced on pp. 143/9 of this *Journal*.

† 23rd March, 1935, p. 343.

between specific gravity and dry rubber content expressed as a weight percentage is not a linear one, and takes the form of a very slightly curved line. The effect of the slight curvature would be to give a higher result for the specific gravity of the rubber phase. He suggests, therefore, that the value of 0.902 derived by Rhodes as a result of straight-line extrapolation is probably slightly low. The formula

$$S_l = \frac{(C_r + C_s)(S_r S_s)}{C_r S_s + C_s S_r}$$

S_l = specific gravity of latex
C_r = weight percentage rubber
C_s = „ „ serum
S_r = specific gravity rubber phase
S_s = „ „ serum phase

covers the relationship between the specific gravities of the rubber and serum phases, the weight percentage of dry rubber and the specific gravity of the whole latex, and by applying it to two pairs of the experimental results published by the writer, De Vries has estimated that a value of 0.9065 for the specific gravity of the rubber phase is probably more accurate than the published figure of 0.902.

The criticism made by De Vries is sound, and it is necessary to correct for the non-linear relationship between weight percentage of dry rubber and the specific gravity of the latex. The experimental results are accordingly analysed in the following pages in the light of De Vries' suggestion.

The Specific Gravity of the Rubber and Serum Phases of Latex

The experimental group-mean points which appear in Table II of the original publication (1) are set out below for easy reference; from these it is possible to calculate values for the specific gravity of "rubber" and serum using the formula

$$S_l = \frac{(C_s + C_r)(S_s S_r)}{C_r S_s + C_s S_r}$$

to which reference has been made earlier.

A value for the specific gravity of the rubber phase and a value for that of the serum phase can be obtained by calculation from any pair of the results in Table I. There are eleven group-mean points, so that it is possible to choose fifty-five different combinations of two D.R.C. points for purposes of calculation. In making his rough estimate of the probable specific gravity values, De Vries made calculations from two pairs only. In order to arrive

TABLE I.

Group D.R.C. per cent. dry weight.	Total samples in Group.	Mean D.R.C. per cent. by weight.	Mean Specific Gravity.
28.1—30.0	97	29.3	0.9831
30.1—32.0	116	31.0	0.9820
32.1—34.0	47	33.0	0.9796
34.1—36.0	59	35.2	0.9773
36.1—38.0	117	37.3	0.9744
38.1—40.0	102	39.1	0.9725
40.1—42.0	104	40.9	0.9706
42.1—44.0	39	43.0	0.9682
44.1—46.0	38	45.2	0.9650
46.1—48.0	85	47.1	0.9626
48.1—50.0	48	48.8	0.9614

at an accurate value it is necessary, as he suggests, to take the average of a larger number of pairs. Calculations have been made from fifty-three of the fifty-five possible pairs, and an average value for the specific gravity of the rubber phase and that of the serum phase obtained. The two pairs which were left out of consideration were the D.R.C. pairs 29.3.-31.0 and 47.1-48.8, which lie at the extreme ends of the D.R.C. range. Every other possible combination was included in the calculation. Table II gives a list of the combinations and the values obtained.

TABLE II

Calculation of values for specific gravity of rubber (S_r) and specific gravity of serum (S_s) from the eleven experimental points of Table I by the application of the formula:—

$$S_1 = \frac{(C_1 + C_2)S_rS_s}{C_rS_s + C_sS_r}$$

Total number of pairs	D.R.C. pairs. A	B	S.G. Rubber (S_r)	S.G. Serum. (S_s)
1	29.3	33.0	.9219	1.0108
2	29.3	35.2	.9178	1.0129
3	29.3	37.3	.9112	1.0164
4	29.3	39.1	.9114	1.0160
5	29.3	40.9	.9115	1.0161
6	29.3	43.0	.9107	1.0165
7	29.3	45.2	.9074	1.0183
8	29.3	47.1	.9064	1.0187

Total number of pairs	D.R.C. pairs. A	B	S.G. Rubber (S_r)	S.G. Serum. (S_s)
9	29.3	48.8	.9087	1.0176
10	31.0	33.0	.9054	1.0206
11	31.0	35.2	.9101	1.0181
12	31.0	37.3	.9047	1.0212
13	31.0	39.1	.9065	1.0200
14	31.0	40.9	.9077	1.0194
15	31.0	43.0	.9076	1.0196
16	31.0	45.2	.9045	1.0212
17	31.0	47.1	.9039	1.0217
18	31.0	48.8	.9067	1.0201
19	33.0	35.2	.9142	1.0156
20	33.0	37.3	.9044	1.0212
21	33.0	39.1	.9069	1.0199
22	33.0	40.9	.9087	1.0197
23	33.0	43.0	.9080	1.0192
24	33.0	45.2	.9045	1.0215
25	33.0	47.1	.9038	1.0218
26	33.0	48.8	.9068	1.0199
27	35.2	37.3	.8951	1.0286
28	35.2	39.1	.9032	1.0229
29	35.2	40.9	.9061	1.0207
30	35.2	43.0	.9065	1.0205
31	35.2	45.2	.9027	1.0232
32	35.2	47.1	.9023	1.0236
33	35.2	48.8	.9059	1.0210
34	37.3	39.1	.9124	1.0156
35	37.3	40.9	.9076	1.0104
36	37.3	43.0	.9103	1.0161
37	37.3	45.2	.9047	1.0108
38	37.3	47.1	.9036	1.0222
39	37.3	48.8	.9075	1.0191
40	39.1	40.9	.9120	1.0156
41	39.1	43.0	.9094	1.0178
42	39.1	45.2	.9024	1.0234
43	39.1	47.1	.9018	1.0239
44	39.1	48.8	.9067	1.0199
45	40.9	43.0	.9073	1.0198
46	40.9	45.2	.8989	1.0273
47	40.9	47.1	.8994	1.0269
48	40.9	48.8	.9058	1.0212
49	43.0	45.2	.8916	1.0353
50	43.0	47.1	.8957	1.0310

Total number of pairs	D.R.C. pairs. A	B	S.G. Rubber (S_r)	S.G. Serum. (S_s)
51	43.0	48.8	.9052	1.0215
52	45.2	47.1	.9003	1.0259
53	45.2	48.8	.9130	1.0127
53	Total	...	48.0388	54.0609
	Average Values	...	0.9064	1.0200

It will be seen that the final average value for the specific gravity of the rubber phase is 0.9064, and that for the serum phase 1.0200. The value of 0.9019 for the specific gravity of the rubber phase is, therefore, corrected to 0.9064.

It now becomes necessary to discover whether or not this correction will have an appreciable effect on the table of figures published as Table V in the original publication (1) for normal preserved latex in the dry rubber content range 28-52%.

Specific Gravity Table for Normal Preserved Latex

By substituting the values 0.9064 and 1.0200 for S_r and S_s respectively, in the formula to which reference has been made, it is possible to calculate values for the specific gravities of latices of any dry rubber content. In this way a specific gravity table can be constructed on the basis of the corrected values for comparison with Table V (1) obtained originally from the straight line $S = -0.001158t + 1.0177$. In Table III this comparison is made.

TABLE III

Showing comparison of values for specific gravity derived from:—

(*a*) the straight line $S = -0.001158t + 1.0177$ (Table V (1)) and

(*b*) from the formula $S_1 = \dfrac{(C_s + C_r) \times 0.9064 \times 1.0200}{C_r \times 1.0200 + C_s \times 0.9064}$

	D.R.C. per cent. by weight.	Specific Gravity. From (*a*) above.	From (*b*) above.
	1	2	3
Experimental zone—	**28.0**	**0.9853**	**0.9854**
	29.0	**0.9841**	**0.9842**
	30.0	**0.9830**	**0.9830**
	31.0	**0.9818**	**0.9819**

	D.R.C. per cent. by weight.	Specific Gravity. From (*a*) above.	Specific Gravity. From (*b*) above.
	1	2	3
Experimental zone—	**32.0**	**0.9806**	**0.9807**
	33.0	**0.9795**	**0.9795**
	34.0	**0.9783**	**0.9783**
	35.0	**0.9772**	**0.9771**
	36.0	**0.9760**	**0.9760**
	37.0	**0.9749**	**0.9748**
	38.0	**0.9737**	**0.9736**
	39.0	**0.9725**	**0.9725**
	40.0	**0.9714**	**0.9714**
	41.0	**0.9702**	**0.9701**
	42.0	**0.9691**	**0.9690**
	43.0	**0.9679**	**0.9678**
	44.0	**0.9667**	**0.9667**
	45.0	**0.9656**	**0.9655**
	46.0	**0.9644**	**0.9644**
	47.0	**0.9633**	**0.9633**
	48.0	**0.9621**	**0.9621**
	49.0	**0.9610**	**0.9610**
	50.0	**0.9598**	**0.9598**
Extrapolation zone—	51.0	0.9586	0.9587
	52.0	0.9575	0.9576
	53.0	0.9563	0.9564
	54.0	0.9552	0.9553
	55.0	0.9540	0.9542
	56.0	0.9529	0.9531
	57.0	0.9517	0.9520
	58.0	0.9505	0.9508
	59.0	0.9494	0.9498
	60.0	0.9482	0.9487
	61.0	0.9471	0.9476

The figures in lighter type are obtained by extrapolation beyond the experimental zone.

The values already published in Table V of the original publication (1) are set out in column 2, while column 3 gives the values derived from the corrected specific gravities of "rubber" and serum.

It is at once apparent that over the whole of the experimental zone, the two tables are to all intents and purposes identical, and that not until by extrapolation a dry rubber content of 57% is reached do appreciable differences begin to be apparent.

In Table IV of the original publication (1) figures were given for the closeness of approach of the experimental points to the line $S = -0.001158t + 1.0177$, and these are again set out in Table IV below in comparison with values derived from the corrected specific gravities for "rubber" and serum.

TABLE IV

Closeness of approach of the group-mean points to :—

(*a*) the line $S = -0.001158t + 1.0177$ (Table IV (1)) and
(*b*) values derived from the formula :—

$$S_l = \frac{(C_s + C_r) \times .9064 \times 1.0200}{C_r \times 1.0200 + C_s \times 0.9064}$$

Mean D.R.C.	Mean S.G. experimental.	S.G. calc. from (*a*) above.	Deviation from exptl. S.G.	S.G. calc. from (*b*) above.	Deviation from exptl. S.G.
29.3	0.9831	0.9838	+0.0007	0.9839	+0.0008
31.0	0.9820	0.9818	−0.0002	0.9819	−0.0001
33.0	0.9796	0.9795	−0.0001	0.9795	−0.0001
35.2	0.9773	0.9769	−0.0004	0.9769	−0.0004
37.3	0.9744	0.9745	+0.0001	0.9744	nil
39.1	0.9725	0.9724	−0.0001	0.9724	−0.0001
40.9	0.9706	0.9703	−0.0003	0.9703	−0.0003
43.0	0.9682	0.9679	−0.0003	0.9678	−0.0004
45.2	0.9650	0.9654	+0.0004	0.9653	+0.0003
47.1	0.9626	0.9632	+0.0006	0.9632	+0.0006
48.8	0.9614	0.9612	−0.0002	0.9612	−0.0002

It will be seen that there is no appreciable difference between the closeness of approach of the two sets of calculated values to the experimental points.

It is, therefore, clear that the original specific gravity table is accurate in the D.R.C. range 28-52%, which covers all commercial requirements for unconcentrated preserved latex. The straight line $S = -0.001158t + 1.0177$ does, in fact, give an accurate picture of the results over the whole experimental range.

It is next required to consider whether or not the substitution of the corrected value for the specific gravity of the rubber phase of latex, weakens materially the deductions which were made in the original publication from the experimental work on settled latex and centrifugal concentrates.

The Specific Gravity of Settled Latex, Centrifugal Concentrates and Centrifugal Concentrate-skim Mixtures

(*a*) *Settled latex and individual samples of concentrate*

In Section B of the original publication (1) it was shown that, by simple gravitational settlement of sludge, specific gravity differences of the order of −0.004 could be observed, and a series of sixty-eight samples of centrifugal concentrate were examined for dry rubber content and specific gravity in order to discover the deviation of the specific gravity from that indicated for normal preserved latex by extrapolation of the straight line $S = -0.001158t + 1.0177$. It was found (see Table VII (1)) that the deviation of specific gravity was of the same order, but in general slightly greater than that observed when normal preserved latex is allowed to undergo gravitational settlement. Table V reproduces Table VII of the original publication (1), together with figures showing the deviation of the experimental results from the specific gravities which are calculated from the corrected values for "rubber" and serum.

TABLE V

Deviation of the specific gravities of centrifugal concentrates from:—

(*a*) the line $S = -0.001158t + 1.0177$ (Table VII (1)) and
(*b*) values derived from the formula:—

$$S_1 = \frac{(C_s + C_r) \times 0.9064 \times 1.0200}{C_r \times 1.0200 + C_s \times 0.9064}$$

Group D.R.C.	No. of samples examined.	Mean D.R.C.	Mean S.G. found.	S.G. Calc. from (*a*)	S.G. Calc. from (*b*)	Deviation from (*a*)	Deviation from (*b*)
56.1—58.0	6	57.2	0.9476	0.9515	0.9518	−0.0039	−0.0042
58.1—59.0	10	58.6	0.9458	0.9498	0.9502	−0.0040	−0.0044
59.1—60.0	21	59.6	0.9442	0.9487	0.9491	−0.0045	−0.0049
60.1—61.0	31	60.4	0.9426	0.9478	0.9482	−0.0052	−0.0056
					Average ...	−0.0044	−0.0048

The use of the corrected values for the specific gravity of "rubber" and serum, increases the deviations slightly, but they remain of the same order as those observed for the gravitational settlement of normal latex, namely, −0.004 to − 0.005.

It was further argued that if the experimental specific gravity values for centrifugal concentrate had been related not to the values derived from the work under reference, but to those obtained

by the extrapolation of the table of the Rubber Trade Association or to those of De Vries, the deviations observed would have been of the higher order of − 0.01. This argument is seen from Table V to require no modification.

With reference to the value of 0.912 derived from the R.T.A. table for the specific gravity of the rubber phase, it should be noted incidentally that this value is obtained by straight-line extrapolation, and since it is equally the practice of the Rubber Trade Association and the Rubber Research Institute to express dry rubber content as a weight percentage, the figure of 0.912 becomes subject to correction in order to make it comparable with the corrected value of 0.9064 now derived from the figures in Table I. When this correction is applied the approximate R.T.A. values for the specific gravities of the "rubber" and serum phases of latex become 0.916 and 1.0133 respectively.

(b) Centrifugal Concentrate-Skim Mixtures

In the original publication, a series of mixtures were made from a quantity of a single centrifugal concentrate of 56.7% dry rubber and its own skim latex, of which the dry rubber content was 15.7%. Dry rubber content-specific gravity relations were obtained for the two primary materials and twelve different mixtures. From these figures a straight-line extrapolation gave a value for the specific gravity of the rubber phase in this concentrate of 0.8966, which deviated by — 0.0053 from the value of 0.9019, which had been similarly derived for "rubber" in normal preserved latex. This deviation was of the same order as that observed for settled latices and individual samples of centrifugal concentrate. The substitution of the De Vries value of 0.914 or the R.T.A. value of 0.912 for the figure of 0.9019 would have given deviations of the order of 0.017 and 0.015 respectively, and this was taken as a further indication that the De Vries value and R.T.A. derived value were probably high.

The value of 0.8966 was derived by straight-line extrapolation from D.R.C. values expressed as a weight percentage, and it therefore requires to be corrected. The fourteen experimental points permit calculations of the specific gravity of the rubber disperse phase to be made from ninety-one different combinations of two D.R.C. points using the formula $S_1 = \frac{(C_r+C_s)\,S_s S_r}{C_r S_s + C_s S_r}$ and the average value for the specific gravity of the rubber phase in the latex concentrate is found in this way to be 0.9011, which deviates from the similarly corrected value of 0.9064 for rubber in normal preserved latex by — 0.0053. This deviation is identical with the figure obtained in the original publication (1). The

deviations from the De Vries value of 0.914 and the corrected R.T.A. value of 0.916 are 0.013 and 0.015 respectively, which are also of the same order as those cited originally. The results obtained by the substitution of corrected for the original values do not, therefore, demand a change in the deductions which were originally made.

Discussion and Conclusions

At the instigation of De Vries, the experimental results which led to the deduction that the specific gravity of the rubber phase of preserved latex was 0.902 have been carefully re-examined, and the value is now corrected to 0.9064. The difference between this corrected value and De Vries' own figure of 0.914, obtained, it should be noted, on fresh latex, is still a large one, and of the order of 0.008. Similarly, the difference between the value of 0.9064 and the corrected value of 0.916 derived from the R.T.A. table remains of the order of 0.01. A re-examination of the supporting evidence advanced in Section B of the writer's original publication does nothing to weaken it, and the reasons for the differing results must for the present remain a matter for some conjecture. De Vries worked with fresh latex of low dry rubber content at a time when it was by no means easy to obtain a rubber-rich material, and he has advanced this and a number of other factors which are possibly contributory to the difference between his final results and those now indicated. There can be no doubt that the specific gravity of the serum must be reduced by the addition of ammonia solution as a preservative. In the original publication no stress was laid on the value for the specific gravity of the serum, because it was felt that it could not be comparable with that of the fresh latex used by De Vries. In our work, however, no added water, except that which is contained in the ammonia solution itself, was present in the samples. De Vries indicates that a low value for the specific gravity of the rubber phase might be expected when the ratio rubber/serum is high, and also enquires what effect on the specific gravity of the "rubber" would be produced by allowing the latex to deposit its phosphates and sludge. Centrifugal concentration provides an artificial combination of the two effects, namely, that of increasing the ratio rubber/serum, and removing extraneous solid matter. In our work on individual samples of centrifugal concentrate this treatment is seen to result in specific gravities lower than those derived for normal latex of the same D.R.C., and in the work on concentrate-skim mixtures the derived value of 0.9011 for the rubber phase itself is also below that of 0.9064 for normal preserved latex. These experiments provide a general indication of the combined effect of the two

factors mentioned, but they do not fully disentangle the effects due to each. It should be mentioned that the determinations made in our work were not made on freshly ammoniated samples. In the original paper (1) it was not pointed out that the samples were examined after periods of time varying from a week to three weeks; the exigencies of other work made it quite impossible to work to a standard storage period. It may be taken, however, that although the samples were not stored for such a long period after preservation as would be the case with latex available for experiments in Europe, they were not examined until the rapid initial changes in D.R.C. noted by Bishop and Fullerton (6) had taken place, and the latex had reached the state in which subsequent change in D.R.C. is slow. In this respect, therefore, our work was not comparable with that of De Vries, and this may account in great part for the difference between his value for the specific gravity of the rubber phase and our own. If one considers the specific gravity table of the R.T.A. in conjunction with the corresponding values in Table III, it will be seen that although the R.T.A. table is based on different values for the specific gravities of the ultimate rubber and serum phases of latex, the figures for commercial latices in the zone covered by the R.T.A. table differ but slightly from those set out in Table III. The values of the R.T.A. were presumably intended only for approximate commercial purposes, and it is unlikely that the differences which do show themselves will disturb either dealers or industrial users.

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